REPORT OF THE SUPERINTENDENT

OF THE

U. S. COAST AND GEODETIC SURVEY

SHOWING

THE PROGRESS OF THE WORK

DURING THE

FISCAL YEAR ENDING WITH

JUNE, 1884.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

A report by J. E. Hilgard, Superintendent, of the progress of the Coast and Geodetic Survey for the fiscal year ending June 30, 1884.

DECEMBER 17, 1884.—Laid on the table and ordered to be printed.

TREASURY DEPARTMENT,
December 16, 1884.

SIR: In compliance with section 4690, Revised Statutes of the United States, I have the honor to transmit herewith, for the information of Congress, a report addressed to this Department by J. E. Hilgard, Superintendent of the Coast and Geodetic Survey, showing the progress made in that work during the fiscal year ending June 30, 1884, and accompanied by a map illustrating the general advance in the operations of the Survey.

Very respectfully,

H. McCULLOCH,
Secretary.

Hon. JOHN G. CARLISLE,
Speaker of the House of Representatives.

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ERRATA.

In Coast and Geodetic Survey Report for 1884.

Page 23, fourth line from bottom, for *companion* read *comparison*.
Page 115, plate number 1663, for *Nahivitti* read *Nahwitti*.
Page 116, chart 600^b, plate number 1755, for *Stait* read *Strait*.

REPORT.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, December 15, 1884.

SIR: In compliance with law and with the regulations of the Treasury Department, I have the honor to submit herewith my report of the progress made in the work of the Coast and Geodetic Survey during the fiscal year ending June 30, 1884.

Up to that date the general progress of the survey is shown graphically in the two maps (sketches Nos. 1 and 2) which accompany this report.

During the past fiscal year field operations have been carried on in thirty States and three Territories, and in the District of Columbia. In conformity with the act of March 3, 1871, trigonometrical surveys were continued in nine States, which have made requisite provision for their own topographical and geological surveys.

The tabular statement in Appendix No. 1 shows the distribution of the field parties, and the nature of the work executed.

It must be apparent upon a brief consideration of the extent of territory now included by law in the operations of the Survey that true economy, based upon a regard for the best interests of the public service, demands for each field party an appropriation based upon a careful estimate of the cost of its transportation to and from the locality of work, and the cost of keeping it in the field during the whole of the season most available for its operations. To be obliged to recall parties for want of funds during the best part of the working season, or to delay sending them till but part of a season's work can be accomplished, are unavoidable results of insufficient appropriations.

I would therefore most earnestly renew the recommendation made in my last annual report that for the next fiscal year the sum appropriated for party expenses should be at least half again as large as it has been of late years. In the "Estimates in detail" I state the amount which can be expended to advantage for this purpose.

The arrangement of the parts of this report is the same as that of last year, Part I being mainly occupied with general statements of progress under the several heads of Field-work, Office-work, Discoveries and Developments, and Special Scientific work, and with a statement and explanation of the estimates for the next fiscal year; in Part II appear the detailed recitals of field-work and a reference to the office-work; in Part III are comprised the several appendices relating to field and office work which are published annually, and such professional papers, discussions, and reports, as illustrate the methods and results of the Survey.

PART I.

Reference may be made to Appendix No. 1, as showing in a geographical arrangement the localities of the several operations in the field, beginning at the eastern part of the coast of Maine, and following southward to the southern point of Florida and thence along the Gulf coast to the Rio Grande; passing then to the southern part of the coast of California and going northward to Alaska; and in the interior States, beginning with those nearest to the Atlantic coast.

Among the more important developments of the past fiscal year, affecting immediately the interests of commerce and navigation, may be mentioned the location of a dangerous ledge in Englishman's Bay, coast of Maine; the development of ledges off Minot's Ledge light house, Massachusetts Bay; the discovery of several dangerous shoals in Monomoy Passage; the location of a dangerous rock off Warren's Point, R. I., and of dangerous ledges in Fisher's Island Sound; the discovery of rocks in East River, N. Y., near North Brother and Riker's Islands, and of a dangerous rock in East River in the prolongation of Twentieth street, near Nes Rock; the survey and development of dangerous shoals off Cape Henlopen, and of important changes of high-water line near that point.

To these and other dangers, attention was promptly called by the publication of "Notices to Mariners."

In the general geodetic work of the Survey, and the special scientific investigations incidental to it, the report enumerates the following operations, which by their importance demand mention here:

The completion at Lake Ontario of the connection of the triangulation of the Coast and Geodetic Survey with that of the Lake Survey; the advance toward completion of the resurveys of Long Island Sound, and of Delaware River and Bay; the survey of the boundary lines between the States of Pennsylvania and West Virginia, for the Joint Commission of those States; the completion at Washington of the series of comparative determinations of gravity with the Kater pendulums; the determination in geographical position of the corner-stones and boundary monuments of the District of Columbia, and the advance toward completion of the topographical survey of the District; the beginning of lines of level of precision connecting the tidal levels of Chesapeake Bay and the Gulf of Mexico with the transcontinental line of geodesic leveling; and the continuation of the primary triangulation near the thirty-ninth parallel for connecting the triangulation of the Atlantic coast with that of the Pacific.

Two officers of the Survey were sent to Europe on special duty during the year; one of them to London, Paris, Brussels, and Geneva to make certain experiments with pendulums and comparisons of standards; the other to represent the Survey at the seventh conference of the International Geodesic Association at Rome.

GENERAL STATEMENT OF PROGRESS.

I.—FIELD-WORK.

ATLANTIC COAST.—Upon the coasts and within the borders of the New England States, the work of the Survey has included the following operations during the fiscal year ending June 30, 1884: Triangulation of the coast of Maine between West Quoddy Head and Cross Island; continuation of the triangulation and topography of Machias Bay and vicinity; hydrographic surveys between Cross Island and Nash Island, in the vicinity of Moos-a-bec Reach, and in Muscongus Bay, coast of Maine; topographic surveys of Harrington River and of Chandler's River Bay, Me.;

completion of the hydrographic surveys of Narraguagus Bay and River, and of Pigeon Hill Bay, coast of Maine; topographic surveys between Goldsborough and Frenchman's Bays, coast of Maine; continuation of the series of tidal observations with self-registering tide-gauge and of meteorological observations at Pulpit Cove, North Haven Island, Penobscot Bay; hydrographic examinations of Pemaquid and Outer Heron Ledges, coast of Maine; geodetic operations continued in the States of New Hampshire and Vermont; examination of ledges in Lake Champlain; reconnaissance for the introduction of additional lines in the triangulation between the Fire Island, Mass., and Epping base-lines; hydrographic examinations in Vineyard Sound, and resurvey of Monomoy Passage, Nantucket Shoals; survey of Gay Head Cliffs to fix position of wrecked steamer; continuation of observations at Providence, R. I., with a self-registering tide-gauge loaned to the city engineer, and of observations with a similar gauge established on the breakwater, Block Island; topographic resurveys of Stonington, Conn., and vicinity; also of the coast of Connecticut in the vicinity of Saybrook and Lyme; hydrographic resurveys of Fisher's Island Sound and its adjacent waters completed; hydrographic resurveys of the eastern part of Long Island Sound and a portion of Block Island Sound; completion of observations with self-registering tide-gauge at Fort Trumbull, New London, Conn.; topographic resurveys of the north shore of Long Island Sound between New London and Four-Mile River, and between Saybrook and Clinton; hydrographic resurvey along the north shore of Long Island Sound between Goshen Point and Hammonassett Point; topographic resurvey of the north shore of Long Island Sound from Bridgeport to Frost Point, and hydrographic resurvey of Black Rock Harbor.

Work upon the coasts, and within the limits of the States of New York, New Jersey, Pennsylvania, and Delaware, has included hydrographic examinations off Shagwong Point, Montauk, Long Island; topographic and hydrographic resurveys in the vicinity of Montauk Point, Gardiner's Bay, and Orient Harbor, Long Island; re-establishment of points of the old triangulation and determination of additional points on Long Island between Horton's Point and Old Fields Point; supplementary triangulation between Eaton's Point and Sands Point, north coast of Long Island, and of the opposite shore for the resurvey of Long Island Sound; completion at Lake Ontario of the connection of the primary triangulation of the Coast and Geodetic Survey with that of the Lake Survey; hydrographic resurvey of the approaches to New York; observations of currents at stations off New York entrance; continuation of series of tidal observations with self-registering tide-gauge at Sandy Hook, N. J.; geodetic operations in the States of New Jersey and Pennsylvania continued; boundary lines between the States of Pennsylvania and West Virginia surveyed and marked; topographic survey of the New Jersey coast continued, from Cape May court-house northward; progress made in the investigations of the physical hydrography of Delaware River and Bay, and in the location of port-warden lines in the harbor of Philadelphia; topographic resurvey of the shores of Delaware Bay nearly completed; advance towards completion of the hydrographic resurvey of Delaware Bay; topographic resurvey in the vicinity of Cape Henlopen completed.

Within the District of Columbia and the State of West Virginia, and upon the coasts and within the boundaries of the States of Maryland, Virginia, and North and South Carolina, the operations of the Survey have included comparative determinations of gravity with the Kater pendulums at Washington, and similar determinations at Baltimore and Washington in connection with the yard and meter pendulums; annual determinations of the magnetic declination, dip and intensity at the station on Capitol Hill, Washington; geographical position of Covington, Va., determined; occupation of stations for determining the position of the corner stones and boundary monuments of the District of Columbia, and the continuation of the detailed topographic survey of the District; topographic resurvey of the shores of Cherrystone Inlet, Va.; topographic surveys of the shores of the estuaries of James and Elizabeth Rivers; hydrographic surveys in the south branch of Elizabeth River, and in North River and Black Bay, Va.; lines of leveling of precision carried from Hagerstown, Md., towards Fortress Monroe, Va.; connection of the astronomical station at Strasburg, Va., with the triangulation; magnetic observations at Strasburg; determination of the longitude of Charleston, W. Va., by exchanges of telegraphic signals with the station at Louisville, Ky., extension westward of the primary triangulation near the thirty-ninth parallel in West Virginia and Ohio; hydrographic surveys in North Landing and North Rivers, Va. and N. C.; and verification of hydrography for the Atlantic Coast Pilot on the coasts of North and South Carolina.

Upon the coast of Georgia, the east and west coasts of Florida; in the approaches to this coast; and upon the coasts and within the limits of the Gulf States, the following operations were in progress or completed: Reconnaissance for the extension of the primary triangulation in Northern Georgia and Alabama towards Mobile; completion of the survey of the east coast of Florida between Lake Worth and New River; observations of currents off the east coast of Florida continued; triangulation of the west coast of Florida in the vicinity of Punta Rasa; hydrographic survey in the vicinity of San Carlos Entrance and topographic survey in the vicinity of Anclote Keys, west coast of Florida; line of levels of precision carried from the Gulf coast near Mobile towards a point on the transcontinental line of geodesic leveling; survey of the Gulf coast to the westward of the Delta of the Mississippi; continuation of the survey of the Gulf coast of Louisiana from Calcasieu Pass eastward; hydrographic survey of the coasts of Texas and Louisiana continued between Galveston entrance and Calcasieu Pass, and reconnaissance for connecting the triangulation in the vicinity of Point Isabel and the mouth of the Rio Grande with Brownsville, Tex.

Pacific Coast.—Upon the coasts and within the boundaries of the States of California and Oregon, of Washington Territory, and of Alaska, field-work has included triangulation and topography of that portion of the California coast between San Diego and Newport; continuation of the series of observations at the magnetic self-registering record station at Los Angeles, Cal.; continuation of the primary trangulation of the coast of California north of Point Concepcion; survey of that part of the coast between Moro and San Simeon; hydrographic survey in the vicinity of Point Buchon; connection of the main triangulation north of Point Concepcion with that near the thirty-ninth parallel; determinations of the force of gravity at San Francisco in connection with similar observations in Alaska; tidal observations with self-registering tide-gauge continued at Saucelito near San Francisco Bay entrance; hydrographic survey of the California coast between Salmon Point and Brushy Point; survey of Siuslaw River entrance, and continuation of the triangulation and topography of Umpquah River, Oreg.; survey of Nestucca Bay, Oreg., and continuation of the triangulation and topography of the Willamette River; hydrographic survey of Gray's Harbor completed, and topographic survey of Hood's Canal, W. T., nearly completed; hydrographic survey made in and near Seabeck Harbor, Puget Sound, W. T., continuation of the trangulation and topography of Possession Sound, W. T., and of the triangulation, topography, and hydrography of the Strait of Fuca; hydrographic reconnaissance of the bays and harbors of Southeastern Alaska continued; tidal observations with self-registering tide-gauge continued at Saint Paul, Kadiak Island, Alaska, and expedition dispatched to Point Barrow, Alaska, for determinations ot gravity and the magnetic elements.

Interior States.—Field work in localities between the Atlantic and Pacific coasts has included the determination of the longitudes of stations in Tennessee, Kentucky, West Virginia, Indiana, and Illinois by exchanges of telegraphic signals with the station at Louisville, Ky., and also observations for the latitude of stations not before determined; continuation of geodetic operations in the States of Kentucky, Tennessee, Ohio, and Indiana; continuation to the eastward of the primary triangulation in Illinois near the thirty-ninth parallel; geodetic operations continued in the State of Wisconsin; occupation of stations for continuing to the westward the primary triangulation near the thirty-ninth parallel in Missouri and Kansas, and stations occupied near this parallel in Nevada and reconnaissance in Utah for the extension to the eastward of the transcontinental triangulation.

Special operations during the fiscal year included the construction of a steamer designed expressly for service on the coast of Alaska; the assignment of an Assistant to duty in charge of the Coast and Geodetic Survey exhibit at the Southern Exposition in Louisville, Ky.; comparisons of standards of weight and measure and investigations relating to determinations of gravity made in Europe by an Assistant designated for that duty; the transportation of important standards of weight and measure from the British standards office, London, to the International Bureau of Weights and Measures, Paris, and the attendance of the Assistant in charge of the Office as a delegate on the part of the Survey at the International Geodesic Conference at Rome, Italy.

II.—OFFICE-WORK.

The usual disposition has been made of all records of field-work in the varied departments of the Survey carried on during the past fiscal year.

All such records of reconnaissance, triangulation, astronomical and magnetic observations, topographic and hydrographic sheets, tidal records, physical geography, hydrography and gravity researches, and those relating to every description of scientific investigation carried on during the year have been registered in the archives and referred to the appropriate divisions of the office.

Drawings of forty maps and charts have been in progress; of this number eighteen have been finished, including twelve photolithographs. Three minute and carefully drawn maps have been made for the use of the Treasury Department, showing the limits of all custom-house districts in the United States.

A new feature has been introduced in the reproduction upon the original scale of important plane-table sheets; thirty-four such sheets have been carefully inked for this purpose.

Numerous drawings and diagrams have been made for illustrations to the annual report, and sixty-nine tracings and drawings have been furnished in answer to calls for information from other Departments of the Government, and from private parties.

Models of the Western Atlantic Basin and of that of the Gulf of Mexico have been made in plaster and progress made upon the large map of the United States.

Eighty-two projections have been made for use of the topographical and hydrographical parties in the field, and fifteen projections have been finished on copper for new charts. Ten new charts have been begun on copper, while seven charts and thirty-six sketches on copper have been completed.

Corrections and additions have been made on four hundred and twenty-six plates; fifty-one thousand and thirty-seven prints have been made from copper; of this number five thousand two hundred and twenty-six were for illustrations to the Alaska Coast Pilot, and ninety-six were transfer-proofs to be printed from stone. Thirty-six basso and fifty-nine alto electrotype plates have been made for office use, also five basso and eight alto plates for other Departments of the Government.

A series of polyconic projection tables based upon the Clarke spheroid, and extending from the equator to the pole, has been computed and is in course of publication.

During the year thirty-three thousand six hundred and thirty-eight copies of charts were distributed, of which number thirteen thousand three hundred and forty-seven were for the use of the several Executive Departments, and for Senators and Representatives.

III.—DISCOVERIES AND DEVELOPMENTS.

General reference has already been made to the discoveries and developments of the past fiscal year affecting the safety of navigation, with mention of the more important of these discoveries. The "Notices to Mariners," printed and widely circulated during the year were as follows:

No. 40 (October 31, 1883) gave the result of the examination of a dangerous rock off Warren's Point, R. I., known locally as "Elisha's Ledge."

No. 41 (November 9, 1883) described dangerous rocks on the coast of Maine, between Old Man and Old Woman Ledges, near Monhegan light-house, and ledges off the Damiscove Islands.

No. 42 (November 13, 1883) reported the discovery of a reef not before known in Eggemoggin Reach, coast of Maine, and described rocks in East River, N. Y., near North Brother and Riker's Islands.

No. 43 (November 26, 1883) gave notice of a dangerous shoal and extension of the point off Cape Henlopen, the existence of which had been developed in the course of the survey of Lower Delaware Bay. A shoal inside of Delaware Breakwater was also reported and described.

No. 44 (December 8, 1883) warned navigators of a sunken wreck in the Potomac River between Blackistone Island and Piney Point.

No. 45 (March 20, 1884) reported that the recent resurveys in the vicinity of Nantucket Shoals

had developed the existence of several dangerous shoals between Shovelful light-vessel and Pollock Rip light-vessel, in Monomoy Passage.

No. 46 (May 27, 1884) contained notes on dangers in Neva and Peril Straits, and on anchorages in Fish Bay, Southeastern Alaska.

No. 47 (May 28, 1884) gave notice of dangerous ledges in Fisher's Island Sound.

No. 48 (May 31, 1884) warned navigators of a dangerous pinnacle rock in East River, N. Y., on the prolongation of Twentieth street. A danger buoy has since been placed on this rock.

No. 49 (June 1, 1884) reported the existence of a dangerous ledge in Englishman's Bay, near the eastern entrance of Moos-a-bec Reach, coast of Maine.

No. 50 (June 10, 1884) described the location of ledges off Minot's Ledge light-house, Massachusetts Bay.

No. 51 (June 30, 1884) gave notice of important changes, produced by the inroads of the sea, at and near Cape Henlopen, and of changes proposed by works of improvement in that vicinity.

The hydrographic examinations and surveys which developed the dangers and obstructions to navigation above enumerated were made by officers of the Navy on Coast Survey service, and are referred to again in Part II of this report in the detailed notices of work in their several localities.

IV.—SPECIAL SCIENTIFIC WORK.

INTERNATIONAL GEODESIC ASSOCIATION.

The importance of the questions to be discussed at the seventh annual conference of the International Geodesic Association, held at Rome in October, 1883, and the desirability of continuing the intimate relations heretofore existing between the Coast and Geodetic Survey and similar organizations in Europe, led to the detail of an officer of the Survey, under authority from the Secretary of the Treasury, as a delegate to that Conference.

The letter of convocation of the Conference having indicated as one of its leading objects the consideration of the question of the unification of longitude by the adoption of a universal prime meridian, and of the unification of time by the adoption of a universal time, the delegate on the part of the Survey was instructed to express the opinions entertained by scientific and practical men in the United States in relation to the same. He was instructed also to take occasion to urge upon the Conference the desirability of expressing an opinion in favor of the several Governments participating in a Diplomatic Conference at Washington, as proposed by this Government, for arriving at a settlement of the questions mentioned.

After due deliberation, the conclusions of the conference, representing fifteen separate nationalities, were formulated in a series of resolutions, to be brought to the knowledge of the several Governments, and recommended to their favorable consideration. This action led to the meeting of the Diplomatic Conference held at Washington in October, 1884.

Special report has been made by the delegate of the Coast and Geodetic Survey in regard to the part taken by him in the discussions.

DETERMINATIONS OF GRAVITY AND COMPARISONS OF STANDARDS.

Reference was made in my last annual report to the detail of an Assistant in the Survey for the purpose of obtaining in Europe certain observations necessary to complete the connection of the American and European initial gravity stations. This duty involved the measurement of the flexure of the Repsold pendulum tripod at the observatories at Kew, England, and Geneva, Switzerland; the charge of the construction of new pendulums and of apparatus for gravity investigations, and special inquiries respecting matters discussed at the Gravity Conference. Papers relating to the method adopted for the measurement of flexure, and to the effect of flexure of a pendulum upon its time of oscillation appear as Appendices 15 and 16 to this report.

Advantage was also taken of this detail to have made comparisons of the iron yard No. 57, belonging to the United States Bureau of Weights and Measures, with its mate, No. 58, deposited in the ordnance office at Southampton, and with the bronze yard No. 6, known as the "generator," and kept at the British Standards Office. The Arago platinum kilogram of the United Statse

Weights and Measures Bureau was transported to the International Standards Bureau at Breteuil, for comparison.

The valuable series of comparative determinations of gravity by means of the Kater pendulums was completed at Washington early in the fiscal year by the Assistant in whose charge they had been placed to be swung at the Transit of Venus station of 1882, at Auckland, New Zealand, at stations in New South Wales, British India, and Japan, and at a station in San Francisco. A full report of these observations appears in Appendix No. 14. At Washington, the station occupied was the one at the Smithsonian Institution, at which these pendulums had been swung by Lieutenant-Colonel Herschel, R. E.

PROJECTION TABLES, AND FORMULÆ AND FACTORS FOR LATITUDE, LONGITUDE, AND AZIMUTH COMPUTATIONS, BASED ON THE CLARKE SPHEROID.

In February, 1880, the Clarke spheroid of 1866 was adopted by direction of the Superintendent as the basis of development of the area covered by the entire operations of the Coast and Geodetic Survey. It superseded the Bessel spheroid, which had been in use since 1844, and its adoption made desirable the preparation of new editions of the Projection Tables, and of the auxiliary tables for the computation of geodetic latitudes, longitudes, and azimuths.

The new Projection Tables appear in Appendix No. 6. They have been computed under the direction of the Assistant in charge of the office, and cover the entire distance from the equator to the pole. Some changes and additions in the body of the tables will, it is hoped, make them more convenient for use. They have been prepared for the polyconic projection,* so long in use upon the survey, but answer equally well for all kinds of conic projections.

In Appendix No. 7 is given a third edition of the Tables of Formulæ and Factors for the computation of geographical positions. The first edition appeared in the Report for 1860, Appendix No. 36, and the second in the Report for 1875, Appendix No. 19. The present edition has been carefully revised by the Assistant in charge of the Computing Division, under whose direction it has been prepared.

THE RUN OF THE MICROMETER.

In Appendix No. 8 is given an investigation of the facts and conditions which should guide an observer in determining for the different fractional arcs measured on the graduation of a theodolite the due apportionment of the run of the micrometer, or the quantity by which the micrometer measures more or less than the prescribed number of the seconds of the graduation.

This investigation is followed by examples showing the forms of record and reduction as employed in actual field-work, and also methods of forming tables of run-corrections by means of which these corrections can be readily applied during the progress of the observations.

Tables of this character, in manuscript form, have long been in use by observers and in the Computing Division of this office.

BOUNDARY LINES BETWEEN THE STATES OF PENNSYLVANIA AND WEST VIRGINIA.

Reference was made in my last annual report to a request from the Joint Commission of the States of Pennsylvania and West Virginia for the detail of officers of the Coast and Geodetic Survey to execute the work of tracing out the boundary line between Pennsylvania and the "Pan Handle" of West Virginia. The two Assistants assigned to this duty completed the survey and marking of the boundary early in the fiscal year, the line adopted by the Joint Commissioners being a straight line through the southwest corner of Pennsylvania and the first stone south of the Ohio River, which had been placed in the meridian of the large granite monument marking the south end of the boundary line between the States of Pennsylvania and Ohio.

Subsequently, with my approval, a further request from the Joint Commission was acceded to—the tracing out of a portion of the boundary between Pennsylvania and West Virginia run-

* See Appendix No. 15, Report of 1880, for an account of this and other projections.

ning eastward along the parallel from the southwest corner of Pennsylvania to the Maryland corner.

Full reports of this work, with detailed maps of the two boundary lines, have been transmitted to the Joint Commission. Duplicates of these reports and maps are preserved in the archives of the Survey.

CONNECTION AT LAKE ONTARIO OF THE PRIMARY TRIANGULATION OF THE COAST AND GEODETIC SURVEY WITH THAT OF THE LAKE SURVEY.

In Appendix No. 9 is given the result of the computation and adjustment of the main triangulation across the State of New York, which connects at Lake Ontario the triangulation of Hudson River and Lake Champlain with that of the United States Lake Survey.

That portion of the triangulation of Lake Champlain which forms the immediate basis of the work across the State of New York was executed between 1876 and 1879, and this work itself between 1880 and 1883. Upon Lake Ontario the work of the Lake Survey was done between 1874 and 1878.

The general accuracy of the Coast and Geodetic Survey work is expressed numerically in the report, and the satisfactory character of the junction of the two Government surveys is pointed out in the length of the line Sodus–Oswego, on the lake shore. The discrepancy amounts to but 1-52800 part of the length of this triangle-side, or about an inch and a quarter to the statute mile. In latitude, longitude, and azimuth, the accordance of results is equally satisfactory.

In making this and other junctions with the triangulation of the Lake Survey, which, as well as our own, has been developed on the Clarke spheroid of 1866, the usefulness of that work will be extended, and its results can readily be brought into harmony with those of the Coast and Geodetic Survey.

LONGITUDES DEDUCED IN THE COAST AND GEODETIC SURVEY FROM DETERMINATIONS BY MEANS OF THE ELECTRIC TELEGRAPH BETWEEN THE YEARS 1846 AND 1885. SECOND ADJUSTMENT.

Appendix No. 11, on longitudes deduced in the Survey from determinations by means of the electric telegraph, is a valuable contribution, in the form of a general table of results for longitude and their probable errors, from the time of inception of the method, and the first transmission of telegraphic signals in 1846 to the middle of the year 1884. It contains also the resulting longitudes of all stations between the measures of which mathematical conditions exist requiring adjustment by the use of the method of least squares.

A preliminary adjustment and report on telegraphic longitude results was published as Appendix No. 6 to the Report for 1880. The paper now referred to gives the results of the second adjustment, and was demanded by the additions made to the field longitude work since 1880. These additions comprise new stations, as well as new conditions between old and new stations. The general table contains one hundred and fifty-seven separate longitude determinations.

In the discussion has been included the longitude of Detroit, Mich., the fundamental longitude station of the United States Lake Survey. A value has been derived also for the longitude of Ogden, Utah, which is the principal point of reference for the longitudes obtained in the United States Geographical Surveys west of the one hundredth meridian.

Reference is made in the report to the relative accuracy of the results of the American and European systems of telegraphic longitudes, and it will be seen from the comparison given of the average probable error of a longitude determination by the two systems that the results of the American system compare favorably in accuracy with those of the European.

TRIGONOMETRICAL DETERMINATION OF THE HEIGHTS OF THE STATIONS OF THE DAVIDSON QUADRILATERALS.

A further contribution to hypsometry is made in an appendix (No. 10), in a discussion of the trigonometrical measures for the heights of that part of the great triangulation of California known as the Davidson quadrilaterals.

The experimental study of atmospheric refraction in connection with meteorological conditions, for the purpose of increasing the accuracy of the determination of heights from observations of zenith distances, has of late years claimed much attention in Europe as well as here, and it is believed that the present paper will be regarded as an advance in this kind of research. It is based upon the theoretical considerations of the atmospheric refraction as given by Jordan, whose researches were found to be most directly applicable in connection with the results deduced from the special experiments made in 1880 on the stations Mount Diablo and Martinez East. These results were given in my report of last year (Appendix 12), and it is there pointed out that trigonometrical hypsometry stands much in need of results from similar direct observations of hourly zenith distances, continued day and night, with corresponding meteorological observations, to be made in localities having a distinct climate, in order that for these special regions the results of their discussion, especially with reference to decrease of atmospheric temperature with increase of altitude, may be advantageously employed in the computations for heights.

COAST AND GEODETIC SURVEY EXHIBIT AT THE SOUTHERN EXPOSITION.

In Appendix No. 18 is given a brief account of the exhibit made by the Coast and Geodetic Survey at the Southern Exposition, held at Louisville, Ky., in the summer and autumn of 1883.

The several branches of field-work of the Survey were illustrated by a collection of instruments and apparatus; the results of the work by sets of the charts and other publications. Sets of standards of weight and measure, and a line and end comparator were sent as specimens of the results of work and of the apparatus employed in the office of weights and measures. The exhibit made by the Government, in which eight other Bureaus were represented beside the Coast and Geodetic Survey, was a marked feature of the Exposition, and to it were confined most of the displays of a scientific character.

Two awards were made to the Survey—one, a medal for the exhibit as a whole; the other, a diploma, for the line and end comparator.

PHYSICAL HYDROGRAPHY.

The advance toward completion of the resurvey of Delaware River and Bay has furnished material for the study of the physical hydrography of that important highway of commerce. A paper foreshadowing the probable results of this study has been submitted by the assistant who has been specially charged with the consideration of this and kindred subjects. Comparisons already made between the recent hydrographic surveys and those of forty years ago have afforded means of determining the nature and extent of physical changes in important localities. A report embodying the results of some of these investigations appears as Appendix No. 12.

The services of the assistant by whom this report was prepared, and who has had charge for some years of one of the hydrographic parties, were made available during a portion of the fiscal year to the United States Advisory Commission for the improvement of the navigation of the Delaware by his detail as consulting engineer.

GEOLOGY OF THE SEA BOTTOM IN THE APPROACHES TO NEW YORK BAY.

The existence of a submarine river-channel in the sea-approaches to New York Bay, as developed by recent hydrographic surveys, has led to a discussion of the probable origin and formation of this channel which will be of interest to geologists and students of physical hydrography. This paper appears as Appendix No. 13.

DEPTHS OF THE SEA IN THE BAY OF NORTH AMERICA AND THE GULF OF MEXICO.

In Appendix No. 17 is described a model of the depths of the sea in the Bay of North America and Gulf of Mexico. The model presents, also, the characteristic features of the eastern part of the North American continent, and shows at a glance the relation of those features to the great submarine basins of the Gulf and the North Atlantic.

EXPLANATION OF ESTIMATES.

The estimates for the Coast and Geodetic Survey are presented under the following heads:

"Party expenses" comprises the pay of those temporarily employed as recorders, signal-men, hands, cooks, drivers, or boatmen, as the case may be, the subsistence and transportation of the parties, and all requisite materials, tents, boats, and all other necessary expenses incident to the work.

"Furnishing points for State surveys" gives the amount proposed for extending the geodetic work in different States.

"Transcontinental geodetic work" proposes the sum to be expended for continuing the triangulation connecting the work on the Atlantic coast with that on the Pacific, including the line of leveling between the two oceans.

"Pay of field officers" comprises the pay of the regular staff of surveyors.

"Pay of office force" comprises the pay of persons regularly employed in the office.

"Office expenses" provides for the purchase of material of all kinds required for the use of the office.

"Rent of office buildings," "Publishing observations," and "Repairs and maintenance of vessels."

The estimates under these several heads are substantially the same as appropriated for during several years past, except the first item, that for "Party expenses," which is increased for the following reasons:

In order to conduct the work with reasonable economy, it is requisite that surveying parties should continue in the field at the several localities where the work is in progress during the whole season of favorable weather. The expenses of moving the parties and their equipments to and from their several localities of work, which are for the main part remote from ordinary facilities, are no greater for a season of seven months than for one of four months. For the sake of maintaining a proper economic relation between party expenses and results, the Superintendent recommends an increase of about one-third in this item.

The additional item of $18,000 for resurvey of New York Bay and Harbor is introduced at the instance of the maritime and commercial bodies of the city of New York. The commercial importance of the port of New York is so great that a constant watch should be kept on the changes in the harbor, and the Department recommends the appropriation asked for this purpose.

The last item, for "Repairs and maintenance of vessels," is $12,000 less than last year, that amount having been specifically appropriated to provide new boilers for the steamer Hassler, which has now been done.

ESTIMATES IN DETAIL.

For every expenditure requisite for and incident to the survey of the Atlantic, Gulf, and Pacific coasts of the United States, including the survey of rivers to the head of tide-water or ship navigation; deep-sea soundings, temperature and current observations along the coasts and throughout the Gulf Stream and Japan Stream flowing off the said coasts; tidal observations; the necessary resurveys; the preparation of the Coast Pilot; a magnetic map of North America; and the compilation of data for a general map of the United States; and including compensation not otherwise appropriated for of persons employed on the field-work, in conformity with the regulations for the government of the Coast and Geodetic Survey adopted by the Secretary of the Treasury, and including allowance for subsistence to officers of the Navy attached to the Survey, not ex-

ceeding $1 per day, as allowed by act of Congress approved June 12, 1858, and also including the repairs, outfit, and equipment of vessels used on the Survey, to be expended under the following heads:

PARTY EXPENSES:

For continuing the survey of the coasts of Maine eastward from Englishman's Bay towards Quoddy Head, and including portions of Passamaquoddy Bay	$10,500
For examination of reported dangers and changes on the eastern coast and necessary resurveys in Nantucket and Vineyard Sounds	3,500
For continuing resurvey of Long Island Sound	21,000
For completing resurvey of Delaware Bay, including current observations	4,500
For continuing examination of changes, and resurveys on the sea coast of New Jersey	3,000
For continuing the survey of estuaries of Chesapeake Bay, and of sounds and tide-water-passages in North and South Carolina not heretofore surveyed	5,000
For continuing the survey of the Saint John's River, Fla	3,000
For continuing the survey of the western coast of Florida from Estero Bay southward and from Saint Joseph's Bay northward, and hydrography of same	9,000
For resurvey of Mobile Bay and supplementary surveys on the east side of the Mississippi Delta	5,000
For continuing the survey of the coast of Louisiana west of the Mississippi Delta, and hydrography on the coasts of Louisiana and Texas	9,000
For making the requisite verification of the work near the boundary, and for examination of entrances on the coast of Texas	3,000
For making off-shore soundings along the Atlantic coast and observations of currents and temperatures in the Gulf Stream	9,000
For continuing the researches in physical hydrography relating to harbors and bars.	5,000
For determinations of geographical positions (longitude party)	5,000
For continuing the primary triangulation from Atlanta towards Mobile	4,500
For continuing an exact line of levels from the Gulf to the transcontinental line of levels between the Atlantic and Pacific Oceans	2,500
For tidal observations on the Atlantic coast, including the establishment of a tide station at Fernandina, Fla	3,500
For continuing magnetic observations on the Atlantic and Gulf coasts	2,000
For continuing gravity experiments	5,000
For continuing the preparation of the Coast Pilot and making special hydrographic examinations for the same	4,000
For continuing the compilation of data for a general map of the United States	2,000
For continuing the topographical survey of the coast of Southern California, including the necessary secondary triangulation and supplementary surveys near San Francisco	9,000
For continuing the primary triangulation of California, including a line of precise levels from Saucelito to the transcontinental line of levels	16,000
For continuing hydrography off the California coast	7,500
For continuing the survey of the coast of Oregon, including off-shore hydrography, and the survey of the Columbia and Willamette Rivers to the head of ship navigation	10,500
For continuing the survey of the coast of Washington Territory	15,000
For continuing explorations in the waters of Alaska and making hydrographic surveys in the same	10,000
For traveling expenses of officers and men of the Navy on duty, and for special surveys that may be required by the Light-House Board or other proper authority, and contingent expenses incident thereto	5,000

PARTY EXPENSES—Continued.	
For continuing tide observations on the Pacific coast	$3,500
For magnetic observations on the Pacific coast	3,500
For traveling expenses of the Superintendent and his party on duty of inspection	1,500
For objects not hereinbefore named that may be deemed urgent	10,000
And ten per centum of the foregoing amounts shall be available interchangeably for expenditure on the objects named.	
Total party expenses	210,500
RESURVEY OF NEW YORK BAY AND HARBOR.—For resurvey of New York Bay and Harbor, including East River to Throg's Neck	18,000
FURNISHING POINTS FOR STATE SURVEYS.—For furnishing points for State surveys	20,000
TRANSCONTINENTAL GEODETIC WORK.—For transcontinental geodetic work, including line of leveling between the Atlantic and Pacific Oceans	36,000
PAY OF FIELD OFFICERS:	
For pay of the Superintendent	6,000
For pay of six Assistants at rates between $3,000 and $4,000 per annum	20,800
For pay of nineteen Assistants at rates between $2,000 and $3,000 per annum	43,000
For pay of twenty-one Assistants at rates between $1,500 and $2,000 per annum	36,000
For pay of nine Subassistants at rates between $1,100 and $1,400 per annum	11,250
For pay of nine aids at rates between $720 and $900 per annum	7,920
Total pay in field	124,970
PAY OF OFFICE FORCE:	
In the office of the Superintendent; of the Assistant in charge (including all suboffices); of the Hydrographic Inspector and of the Disbursing Agent, twenty-nine persons from $400 to $3,000 per annum	34,800
In the Computing and Tidal Divisions, twelve persons from $500 to $2,000 per annum.	14,800
In the Drawing and Engraving Divisions, thirty-seven persons from $500 to $2,400 per annum	54,400
In the Miscellaneous Division and the Instrument Shop, twenty-five persons from $300 to $2,400 per annum	25,400
Total pay of office force	129,400
OFFICE EXPENSES:	
For purchase of new instruments, for material and supplies for instrument shop, carpenter shop, and drawing division, and for books, maps, and charts	12,600
For copper plates, chart paper, and printers' ink; copper, zinc, and chemicals for electrotyping, engravers' and printers' supplies; extra engraving and photolithographing	14,200
For stationery for office and field parties; transportation of instruments and supplies; office wagon and horses; fuel and gas; telegrams; ice; washing and extra labor; and allowances to assistants in charge of office details, in accordance with the regulations of the Secretary of the Treasury	13,450
For office furniture and repairs; traveling expenses of assistants and others sent on special duty in the service of the office, and for miscellaneous expenses and contingencies of all kinds	3,950
Total office expenses	44,200

Rent of Office Buildings:	
For rent of buildings for offices, work-rooms, and workshops in Washington	$10,500
For rent of fire-proof building No. 205 New Jersey avenue, including rooms for standard weights and measures; for the safe keeping and preservation of the original astronomical, magnetic, hydrographic, and other records; of the original topographical and hydrographic maps and charts; of instruments, engraved plates, and other valuable property of the Coast and Geodetic Survey	6,000
Total for rent of office buildings	16,500
Publishing Observations.—For continuing the publication of observations and their discussion, made in the progress of the Coast and Geodetic Survey, including compensation of civilians engaged in the work, the publication to be made at the Government Printing Office	6,000
Repairs and Maintenance of Vessels.—For repairs and maintenance of vessels used in the Coast and Geodetic Survey	30,000
Total amount estimated for United States Coast and Geodetic Survey for 1885–'86	635,570

OBITUARIES.

RICHARD D. CUTTS, Assistant, United States Coast and Geodetic Survey, died in Washington on December 13, 1883.

Mr. Cutts was born in Washington, September 21, 1817. Having been appointed Subassistant in the Coast Survey, June 1, 1843, under the Superintendency of Mr. Hassler, he reached the grade of Assistant under Superintendent Bache less than three years later. That the fine abilities and untiring energy of Mr. Cutts were fully appreciated by Professor Bache is shown, not only by the rapid promotion accorded to him, but also by his assignment to duty in positions of great responsibility, where quick perception, sound judgment, and a readiness to meet every emergency of his profession were essentials.

For five years during the early times of the settlement of California he was in charge of the triangulation and topography upon that coast; upon being relieved from that duty in 1855, he was appointed United States surveyor under the reciprocity treaty with Great Britain; in 1861 he became a member of General Halleck's staff and served with distinction till the close of the civil war. Soon after Professor Peirce became Superintendent he was appointed by that eminent geometer inspector of the secondary triangulation of the Survey, in order to introduce a more thorough system into the field-operations; in March, 1873, the President sent him as honorary commissioner to the Vienna Exposition; at the date of his assignment in 1881 to the charge of the Coast and Geodetic Survey Office, he had completed the connection of the primary triangulation of the New England coast with that of the Hudson River and of Lake Champlain.

His failing health under the steady pressure of office duty excited grave apprehension among his friends, but their hope was that his journey to Rome as the representative of the United States at the annual meeting of the International Geodesic Association would recruit his strength and insure his being spared to them and to the work for some years to come. This hope was not destined to be fulfilled. On his return he was warmly welcomed, and soon resumed the active charge of the office. But signs of failing health were only too evident. He remained at his post, though, till he was prostrated by an attack which in less than a week had a fatal termination. With his associates on the Survey his remembrance will ever be present as that of a valued friend, a man of warm heart, instinctive honor, great ability, and thorough devotion to the interests of the Survey.

ACTION TAKEN AT THE OFFICE OF THE COAST AND GEODETIC SURVEY.

At a meeting of the Assistants and other persons employed in the Coast and Geodetic Survey, held at the office of the Survey, December 15, 1883, upon the occasion of the death of Richard D. Cutts, Assistant in charge of the office and topography, the Superintendent, having taken the chair, spoke as follows:

> There devolves upon me the painful duty of announcing the death of one of our oldest and most faithful associates.
>
> Richard D. Cutts, Assistant, United States Coast and Geodetic Survey, died in this city on December 13, 1883, in the sixty-seventh year of his age and the forty-first year of his service on the Coast Survey.
>
> Assistant Cutts was born in Washington, D. C., in September, 1817, and entered the Coast Survey in June, 1843. An experience previously acquired upon the North-east Boundary Survey, added to his native ability, soon brought his name into prominent notice; and the prompt and efficient discharge of every duty assigned showed how well placed was the confidence so early reposed in him.
>
> During his connection with the Coast Survey his labors have been extended into every department of the work. In his earlier years his efforts were directed towards raising the standard of topographical work, which he did with eminent success. Of late years the higher scientific work of the Survey has occupied his attention, and his operations have extended to all parts of the country. The shores of the Chesapeake, the coasts of the Pacific, the plains of Texas, and the mountains of New England equally bear testimony to his professional ability and untiring energy. To him the navigators of the Pacific are indebted for the first surveys of San Francisco, San Diego, and Monterey Bays, and some other minor harbors on that coast.
>
> On several occasions he has represented this Government in international matters.
>
> In 1855 he was appointed as United States surveyor upon the International Fish-

eries Commission for the settlement of the limits of the fishing grounds between the United States and the British dominions in North America.

Throughout the civil war he performed distinguished services, retiring with the honorary rank of brigadier-general.

In 1873 he was one of the United States Commissioners to the Vienna Exposition; and only two months before his death he attended the International Geodesic Conference at Rome, as the representative of the United States in that conference, which was held with the special view of considering the question of a universal prime meridian and the unification of time.

For two years before his death he filled the position of Assistant in charge of office and topography, and the manner in which he discharged the arduous duties devolving upon him was but in keeping with his discharge of every trust confided to him.

Distinguished as he was for his professional acquirements, he was even more noted for the possession of every quality that marks the perfect gentleman. Wise in counsel, firm in purpose, unswerving in principle, gentle in manner and kind in heart, he was a man without fear and without reproach; and to us who remain behind he leaves an example worthy of our highest emulation.

Remarks were made by Assistants Edward Goodfellow and H. G. Ogden, and by Commander C. M. Chester, U. S. N., Hydrographic Inspector.

The following telegrams, addressed to the Superintendent from Assistants unable to be present were read:

From Assistant Boutelle:

Say for me that I grieve with you for the accomplished officer and noble gentleman whom we all loved so dearly.

From Assistant Davidson:

The Assistants on the Pacific join in the sorrow of those on the Atlantic in the grievous loss of General Cutts. His devotion to the work of the Survey, his ability in execution, and his integrity in administration commanded the respect and admiration of all his brother workers.

To the older officers he was endeared by the early associations and anxieties of the Survey in the beginning; to the younger ones by his active interest in its continued success and development; to all by the ready sympathy and genial encouragement of a great heart and a clear head.

We appreciate but cannot express in words the deep bereavement of his family.

The following resolutions were then unanimously adopted, after which the meeting adjourned.

"1. That the able and faithful services of General Cutts during the forty years of his labors on the Survey and his fidelity to the public interests in the discharge of the responsible duties of his position make his loss one to be deeply deplored.

"2. That the traits happily combined in the character of our honored associate, his sound judgment, absolute integrity, and kindliness of heart gained for him the respect and confidence of his brother officers, and the warm attachment of his friends.

"3. That the officers and members of the Survey assembled here to-day desire to have placed on record this expression of their great loss, both personal and official, and they would ask the privilege of extending their deep sympathy to the family of General Cutts in their bereavement."

FERDINAND H. GERDES, Assistant, United States Coast and Geodetic Survey, died in Washington, June, 27, 1884, in the seventy-fifth year of his age.

Mr. Gerdes was not only the oldest of the Assistants, but the senior on the work in point of service, having entered the Survey as Subassistant in June, 1836. He was born in Hanover, Germany, September 15, 1809. The training he had received in the land of his birth had its usual character of thoroughness, and was enforced by habits of close application and unremitting labor upon the part of its recipient. He rose rapidly in his profession, and was appointed Assistant in March, 1837, and assigned by Superintendent Hassler to the charge of a topographical party on the shores of Long Island Sound.

Between 1841 and 1844 he was engaged in primary triangulation in New Jersey and Maryland, and in topographical work on Delaware Bay and River.

In 1844, when the need of beginning the survey of the coast of the Gulf of Mexico became manifest, Superintendent Bache showed his appreciation of Mr. Gerdes' capabilities by assigning to him the charge of that important reconnaissance, and the execution of the triangulation that it

should develop. He thus became the pioneer of the Survey on that coast, and was identified for many years with its progress.

Soon after the outbreak of the civil war he was assigned to special service with the Gulf Squadron under command of Admiral Farragut, and subsequently to duty on the Mississippi, Yazoo, and Arkansas Rivers in the fleet commanded by Admiral Porter. Both of these officers acknowledged the valuable co operation of Assistant Gerdes, and attributed to his work much of the success of the naval operations.

Towards the close of 1864, a commission having been authorized by Congress to examine and report on sites for a navy-yard in Western waters, Assistant Gerdes accompanied the commission as topographer, and on being relieved from that duty was directed to report to Admiral S. P. Lee to continue surveys on the Mississippi between Cairo, Ill., and Saint Mary's, Mo., and on the Tennessee and Lower Ohio. The reconnaissance charts which were among the results of these surveys were highly appreciated by the officers of the Mississippi squadron.

For the two years following the close of the war Mr. Gerdes was in charge of the hydrography of the Passes of the Mississippi; between 1867 and 1875 he was engaged on special surveys in which his long experience on the work had become of exceptional value. During this period he made a resurvey of the approaches to New York for the Harbor Commissioners; an elaborate report for the Light-House Board on changes in the channel of the Hudson with reference to the location of lights on that river between Hudson and Albany, and completed a topographic and hydrographic survey of the Raritan River and Valley from South Amboy to New Brunswick. His strong constitution and robust frame succumbed but slowly to the infirmities of advancing age and the inroads of ill health, and his indomitable energy kept him part of every season in the field till within little more than a year before his death. His last duty was performed on Long Island in the winter of 1882–'83, when he gave his personal supervision to work at a time when the ground was frozen and often covered with snow.

In the death of JOHN R. BARKER, draughtsman and artist, which occurred February 28, 1884, the office has sustained a serious loss. Mr. Barker was born in Philadelphia, April 29, 1824, and in early life served as passed midshipman in the Navy. Resigning to enter upon civil pursuits, he cultivated his taste for the arts, and in 1873, having entered the service of the Coast Survey, was assigned to duty in making the views required for the Coast Pilot. The graphic delineations of the approaches to nearly every harbor on the Atlantic coast, and the artistic sketches of prominent headlands and other features which illustrate the volumes of that work are due to his skillful pencil. Some of the finest of his views are those of the Hudson River. About two years before his death, Mr. Barker took up the art of etching, and with great success, many of the views of harbors on the southern coast being from his own etchings. His quickness of perception, skill in execution, and entire devotion to his work cannot easily be replaced.

Mr. A. SENGTELLER, who had served continuously in the office as topographical engraver for twenty-seven years died on the 11th of August, 1883. He was a native of Poland, but came to this country from Paris in 1856. His work was marked by strong characterization of topographical details, combined with harmony of tone, and many of our best charts bear witness to his skill. Mr. Sengteller had reached his seventieth year.

Mr. GORDON A. STEWART, keeper of the archives, died after a prolonged illness November 19, 1883. Mr. Stewart was born in the town of Monroe, State of Ohio, April 18, 1833. He received a legal education, and had entered upon the practice of the law just before the beginning of the civil war. In April, 1861, he volunteered in an Ohio regiment, and rose rapidly to distinction, having reached the grade of lieutenant colonel not very long after his enlistment. Hardship and exposure in the field gradually undermined his health, and in 1864 compelled his retirement from the Army. His connection with the Coast and Geodetic Survey Office began in 1874 in the capacity of librarian; in 1875, he was transferred to the archives, where he remained till his death. His last years were passed in suffering from a disease, the seeds of which were sown during his service in the war.

Mr. A. YEATMAN, who had been in the employ of the office for thirty-one years as carpenter, died on the 2d of December, 1883, in his sixty-eighth year. Mr. Yeatman had been master carpenter since 1856. He gave to the work intrusted to him his best skill as an artisan, and devoted to it the scrupulous care and integrity which were characteristic of him as a man.

PART II.

Statements in detail of the operations of the parties of the survey, afield and afloat, are given in this part of the report in a geographical order, and arranged under the heads of the several sectional areas into which for convenience of reference the territory of the United States has been divided.

Beginning at the northeastern part of the coast of Maine, work upon the coasts and within the borders of the New England States is noticed, proceeding thence to accounts of work done upon the coasts and within the boundaries of the Middle and Southern States; thence to the Pacific States, commencing at the southern part of the coast of California and proceeding northward to Alaska, and thence to the work executed in the interior States. A tabular statement of the distribution of the several parties, the names of the persons engaged in the work, and the nature of the work performed appears in Appendix No. 1.

The charge of the Coast and Geodetic Survey Office was continued with Assistant Richard D. Cutts until his assignment to duty as a delegate to the annual conference of the International Geodesic Association at Rome in October, 1883. During his temporary absence Assistant Charles A. Schott was directed to act in his stead.

On the return of Assistant Cutts towards the close of November, he resumed his duties as Assistant in charge of the office, though evidently in failing health. Early in December, he was prostrated by an attack which on the 13th of that month proved fatal. This sad event called forth from his associates on the work expressions of their deep sense of personal loss, and tributes of respect to his memory, which are placed upon record in Part I of this report.

Until January 7, 1884, Assistant Charles A. Schott was acting as Assistant in charge. At that date Assistant Charles O. Boutelle, who had been designated to succeed Assistant Cutts, entered upon his duties. The report of the operations of the office during the fiscal year, accompanied by the reports of the chiefs of its several divisions, as presented by the Assistant in charge, appears in Appendix No. 4.

Commander C. M. Chester, U. S. N., Hydrographic Inspector, has submitted a comprehensive report of progress during the fiscal year in the several branches of hydrographic work committed to his charge. These include the care and maintenance of the vessels of the Survey; the direction of details of hydrography under my general instructions, and the oversight of the work of the hydrographic draughtsmen in the office. This report, which appears as Appendix No. 5, bears witness to Commander Chester's careful and energetic supervision of all operations under his charge.

Special reference is made in it to the valuable assistance rendered him by Lieut. J. E. Pillsbury, U. S. N., on duty as assistant hydrographic inspector, in charge of chart corrections, &c., up to January 29, 1884, and after that date by Lieut. Jefferson F. Moser, U. S. N. Upon being detached from office duty, Lieutenant Pillsbury was instructed to take charge of the preparation of the manuscript of the Atlantic Coast Pilot from Cape Henry southward. The verification by actual inspection of the courses and distances, and the collection of the latest data for this volume involved hydrographic service on the outside coast, reference to which will be made under the heads of Sections IV and V in this part of my report.

Much of Commander Chester's time during the year was necessarily devoted to the performance

of his duties as inspector on the part of the Government of the construction of the steamer Carlile P. Patterson, for service on the coast of Alaska. Lieut. Richardson Clover, U. S. N., who had been associated with Commander Chester in the preparation of the plans and specifications of the new vessel was assigned to the immediate oversight of the details of construction in New York, while Passed Assistant Engineer H. N. Stevenson, U. S. N., superintended the construction of the machinery at Philadelphia. The Patterson was successfully launched January 15, 1884, and is now on her voyage to the Pacific. A full report of her construction, equipment, and adaptability to the special service for which she was designed will be prepared by Commander Chester at as early a date as practicable.

SECTION I.

MAINE, NEW HAMPSHIRE, VERMONT, MASSACHUSETTS, AND RHODE ISLAND, INCLUDING COAST AND SEA-PORTS, BAYS, AND RIVERS. (SKETCHES NOS. 1 AND 3.)

Triangulation of the coast of Maine between West Quoddy Head and Cross Island.—In order to determine the points required for the continuation of the topographical and hydrographical survey of the eastern coast of Maine, Assistant O. H. Tittmann organized a party in pursuance of instructions issued in July, 1883. The secondary and tertiary triangulation which he executed covers the ground between West Quoddy Head and the eastern end of Cross Island. Stations were established about a mile apart along the shore between the points mentioned, and, with but few exceptions, were marked by holes drilled into the solid rock, so as to be permanent and easily recoverable. The smoke of forest fires burning in the locality of the work seriously interfered with its progress. Field operations were closed about the middle of October. The statistics are as follows:

Number of signals erected	28
Number of stations occupied	15
Number of points determined	31

All of the records and computations relating to the work have been transmitted to the office. Duty subsequently assigned to Assistant Tittmann will be referred to under the heads of Sections V and VIII.

Triangulation and topography of Machias Bay and vicinity.—In continuation of the topographical survey of Machias Bay and vicinity, and of the incidental triangulation, Assistant C. H. Boyd took the field, in pursuance of instructions, early in July, and having determined in position the points needed, carried the survey of the shore-line from Cow Point, on the east side of Mason's Bay, around Little Kennebec Bay and the Point of Main, joining the Machias Bay shore-line surveyed in 1882 at Starboard Creek. This work is in the towns of Jonesborough, Machias, and Machiasport.

The shore-line of Holmes Bay was then completed in the towns of Machiasport, Whiting, and Cutler to a junction with the survey of 1882; thus finishing the shore-line survey of the mainland, the islands and the ledges of Little Kennebec and Machias Bays, both branches of Machias River to the first bridges, and of Holmes Bay and the western face of Cross Island.

As regards weather, the season was generally a favorable one, except during the month of September, when the atmosphere was obscured by dense smoke from forest fires.

Mr. T. P. Borden rendered efficient assistance in the work of the party. For the field operations, which closed October 15, the following statistics are reported:

Number of stations occupied in triangulation	4
Number of angles measured	58
Number of geographical positions determined	10
Miles of shore-line surveyed	50
Miles of roads surveyed	5
Area surveyed in square miles	15

Hydrographic surveys between Cross Island and Nash Island; in the vicinity of Moos-a-bec Reach, and in Muscongus Bay, coast of Maine.—The Coast and Geodetic steamer Gedney, under command of Lieut. E. M. Hughes, U. S. N., Assistant Coast and Geodetic Survey, left New York July 3, 1883, in

pursuance of instructions directing that officer to continue off-shore soundings westward from Cross Island at the entrance of Machias Bay, and to make a detailed hydrographic survey of Mud Hole Channel between Head Harbor Island and Great Wass Island. Upon the arrival of the Gedney at Machiasport, Me., July 10, work was actively begun; signals were established at every interval of clear weather, and a few lines of offshore soundings were run, but as the frequent fogs, with smoke from forest fires, retarded this part of the work greatly, it was decided by Lieut. Commander A. S. Snow, U. S. N., Assistant Coast and Geodetic Survey, who had relieved Lieutenant Hughes in command August 15, to give attention for a time to the inshore soundings entirely.

Not unfrequently the sheet of water between Head Harbor and Great Wass Island, the locality of the boat work, would be comparatively free from smoke and fog, while the off-shore signals, standing higher on the islands, were completely hidden from view.

By the 29th of September, the atmosphere being much clearer, and the survey of Mud Hole Channel and vicinity having been practically completed, off-shore soundings were again begun and carried on until the close of the season.

With reference to the hydrographic survey of Mud Hole Channel, Lieutenant-Commander Snow remarks that his sheet, scale 1-10000, covers the area between Head Harbor, Steel Harbor, and Great Wass Islands (locally known as Eastern Bay, in contradistinction to Western Bay, to westward of Great Wass Island), and includes Head Harbor between Steel Harbor and Head Harbor Islands. It offers several harbors of refuge to coasters who are familiar with the locality, is much used in heavy weather, and may be easily entered by any one provided with a chart. It provides also a passage to Moos-a-bec Reach from the sea, which is often used by fishermen and small vessels familiar with the locality, but as this passage is tortuous, beset with dangerous ledges, not buoyed, and accessible only to light-draught vessels having a leading wind, it should not be attempted by strangers.

Owing to the large number of ledges, it was deemed necessary for the proper development of the bottom to run the lines of soundings no farther apart than one hundred meters, and this distance was maintained, except nearer the sea, when it was increased to two hundred meters in deep water. The general direction of the lines was parallel to the general trend of the shores; these lines being crossed by normals to the shore. All of the ledges with regard to which any information could be obtained, or which were suspected by the character of the soundings, were visited at low water, and two hundred and ten positions and soundings taken and reduced to the plane of reference, the ledges being mostly uncovered at mean low water. In all cases of uncertainty, or where the lines did not cross in a satisfactory manner, they were run over a second time. The character of the bottom, except on ledges, is generally soft mud.

Full details and descriptions—the results of very close examinations—are given in Lieutenant-Commander Snow's report respecting the rocks and ledges in Mud Hole Channel and vicinity. Soundings were taken also to the westward of Fisherman's Island, to develop the bottom in the vicinity of Egg and Sea Horse Rocks, and lines were run with the ship parallel to the general trend of the shore, and quite near to it, from Sea Horse Rock to Head Harbor Island.

The lines of off-shore soundings were run out to distances of 10 miles, and about eight-tenths of a mile apart, beginning with the most westerly line, near Nash Island, and carried to the eastward—as weather permitted—to Cross Island, near the eastern limit of the projection. Starting from the coast in from twenty to forty fathoms (which is obtained in close proximity to it), the lines were run in a south by east direction the required distance, then east by north eight-tenths of a mile, then returning to the coast north by west. When the coast was reached at an early hour, shorter intermediate lines were run about two miles off shore and back. Crossing lines were also run at a distance of two and four miles from the coast.

The soundings were found to be very irregular, varying from twenty to ninety fathoms, and the bottom, as shown by the specimens obtained, is generally brown mud, with shells.

No regular observations of currents were made in consequence of there being no anchorage for the vessel off the coast, but observations of the drift were obtained during the progress of the work, and a current of three-quarters to one knot found, the flood tide setting to the eastward, the ebb to the westward. Between Great Wass and Fisherman Islands the ebb tide sets *up* the bay, escaping to the westward through the various passages. From the Eastern and Machias

Bays the ebb sets to the southward, until it meets and joins the current near the coast, when it turns to the westward.

To obtain a plane of reference for the soundings, observations of the tides were made daily near the steamer's landing at Jonesport, between the hours of 6 a. m. and 7 p. m., every fifteen minutes, from July 20 to October 31, inclusive. A supplementary tide gauge was established on Steel Harbor Island, which was connected with that at Jonesport by simultaneous observations.

The old bench-mark at Jonesport could not be found. A new one was established, and the reductions for all soundings were computed from the tidal observations (during the hours above named) of two lunar months.

Lieutenant-Commander Snow's survey developed a dangerous ledge in Englishman's Bay, near the eastern entrance of Moos-a-bec Reach, the least depth over it being nine feet. "Notice to Mariners No. 49," issued in June, 1884, gives the bearings of this ledge, with directions for avoiding it.

On November 1 the Gedney left Jonesport, and on her way to New York Lieutenant-Commander Snow made an examination of the locality between Old Man and Old Woman Ledges, southeast of Muscongus Bay, near which a dangerous ledge had been reported by Maj. C. W. Raymond, United States Engineers. A ledge of small extent, having a depth of 12 feet over it, was found, and the bearings and distances of prominent points in the vicinity were given in "Notice to Mariners No. 41."

The officers attached to the Gedney were Ensigns H. M. Witzel, T. M. Brumby, A. L. Hall, and J. H. Hetherington, U. S. N. For the interest which they took in the progress of the work and their zeal for its advancement, Lieutenant-Commander Snow expresses high commendation. The statistics of the survey are as follows, including the work off Muscongus Bay:

Miles run in sounding	584
Angles measured	6,035
Number of soundings	13,430

Later in the fiscal year Lieutenant-Commander Snow was transferred to duty on the Pacific coast. Mention of this will be made under the heading of Section XI.

Topographical surveys of Harrington River and of Chandler's River Bay, Me.—Under instructions issued in July, 1883, Assistant Eugene Ellicott proceeded to Jonesport, Me., and toward the close of that month began the work of filling in topography upon a sheet which had been begun by Assistant Dennis, comprising Harrington River, Ripley's Neck, and the town of Harrington, Washington County, Me. This sheet was completed near the end of August. Mr. Ellicott then took up the survey of the western shore of Chandler's River Bay, and carried it around the shores of Mason's Bay, and thence to include both shores of the entrance to Chandler's River.

During part of the season disastrous forest fires raged in the immediate vicinity, causing much delay in the work by dense smoke.

The statistics are:

Shore-line surveyed, miles	23
Roads, miles	19
Area of topography in square miles	18

Mention will be made under the head of Section III of duty subsequently assigned to Assistant Ellicott.

Completion of the hydrographic surveys of Narraguagus Bay and River, and of Pigeon Hill Bay, coast of Maine.—Having organized his party on board the schooner Eagre, in pursuance of instructions received in June, 1883, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, upon arriving in Narraguagus Bay, early in July, began the hydrographic survey of that part of the bay included between its entrance and Half Tide Ledge.

The projection, scale 1–10000, which was furnished to him for this survey, included also the upper part of Pigeon Hill Bay. Lieutenant Heald's work exhibits a very complete development of this locality by close lines of soundings, joining on the westward with Lieutenant Colby's survey of 1882, and on the southward with that of Lieutenant-Commander Jewell in 1878. A careful

survey of the Jordan's Delight Ledge, lying southeast of the island of that name, had been kept in view during the progress of the work, but at no time during the season were the conditions of sea, tide, and weather, in the very exposed position of this ledge, favorable to success.

The upper sheet of Lieutenant Heald's work includes the head of Narraguagus Bay and the Narraguagus River to Millbridge on a scale of 1-10000.

Local authorities were consulted upon every available occasion as to the existence of hidden dangers, but in no case were any named that had not already been indicated by the soundings.

Tidal observations were made at Millbridge Steamboat Wharf and at a point on the western shore of Pigeon Hill Bay.

Lieut. David Daniels, U. S. N., and Ensigns O. G. Dodge and Alfred Jeffries, U. S. N., were attached to the party. Upon the completion of the work, toward the close of October, Lieutenant Heald proceeded in the Gedney to New York.

The statistics of his survey are:

Miles run in sounding	413
Angles measured	3,166
Number of soundings	28,900

During the following winter, Lieutenant Heald conducted a hydrographic survey on the Gulf coast, reference to which will be made under the head of Section IX.

Topographical surveys between Gouldsborough and Frenchman's Bays, coast of Maine.—The special topographic work assigned to Assistant A. W. Longfellow by instructions dated in June, 1883, was the filling in of additional topographical details upon certain sheets which had been partly completed by Assistant Rockwell in 1862 and 1865, but upon which, for the purposes of the engraved charts, it was desirable to have the roads and buildings shown, as well as the ground contours of the interior.

Having arrived in the field at Winter Harbor about the middle of July, Mr. Longfellow found it necessary to select and determine with the plane table numerous supplementary signals, the country being found to be very rough and so overgrown with trees and bushes as to be extremely difficult of access and affording but little outlook or command of the ground. Not unfrequently, after the occupation of a station, the plane table had to be dismounted and packed in order to reach the next one.

Extensive forest fires raged in Gouldsborough and on Mount Desert during August, and at times approached so near the locality of work as to threaten the headquarters of the party.

By the middle of October, when field operations were discontinued, the topography had been finished over the area of Schoodic Peninsula, around the shores of Winter Harbor, and to a point about three and a half miles north of it. The statistics of the survey are:

Shore-line surveyed, miles	2
Ponds, creeks, and streams, miles	18
Roads, miles	34
Area of topography in square miles	9

Assistant Longfellow, in his report of the season's work, acknowledges the valuable assistance rendered by Subassistant W. Irving Vinal.

Series of tidal observations with self-registering tide-gauge continued and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay.—The valuable series of tidal and meteorological observations at Pulpit Cove, North Haven Island, which was begun in 1870, has been kept up continuously by Mr. J. G. Spaulding. This series, if continued a few years longer, will complete the shortest lunar period required for a theoretical discussion of the laws of the tides on the Atlantic coast of the United States, and for the purposes of this discussion will supply a series of observations, almost uninterrupted, at a fundamental station.

During the extreme cold of winter the apparatus for circulating hot water to prevent freezing in the float-tube has always proved efficient; without it the record could hardly have been kept continuous. Meteorological observations are taken daily.

Hydrographic examinations on Pemaquid and Outer Heron Island Ledges, coast of Maine, and Ipswich Harbor entrance, coast of Massachusetts.—Depths having been reported much less than now shown on the charts on the Pemaquid and Outer Heron Ledges, to the eastward and southward of Booth Bay entrance, Lieut. J. E. Pillsbury, U. S. N., assistant hydrographic inspector Coast and Geodetic Survey, was directed in June, 1883, to proceed to Booth Bay, and examine the ledges referred to. His instructions included also a visit to Ipswich, Mass., to examine the vicinity of the entrance to Plum Island Sound, so as to determine the extent of changes in that locality. With reference to the shores in this neighborhood, Lieutenant Pillsbury remarks that, being composed almost wholly of sand, nearly every winter gale changes the conformation of the shore-line as well as of the bottom, and that the range-beacon has not unfrequently to be changed to follow the movements of the channel from about a northeast course to one to the southward of east. The recommendations submitted by Lieutenant Pillsbury will be considered in the preparation of future editions of the chart of Ipswich and Annisquam Harbors. While in Portland, on his way to Booth Bay, a ledge, known locally as "Southeast Ledge," off the Damiscove Islands, was reported as dangerous, and upon examination Lieutenant Pillsbury found a small patch of rock having a depth of seven fathoms upon it at mean low water. Another ledge, called "Poor Shoal," of the same character, having a depth of six and three-quarter fathoms over it, was found to the southward and eastward of Bantam Rock. The bearings and distances taken from these ledges were published as part of "Notice to Mariners No. 41." While not dangerous in smooth weather, they become so when a heavy sea is running.

Lieutenant Pillsbury's examination of Outer Heron and of Pemaquid Ledges showed least depths of 8¾ and 11½ feet, respectively.

Continuation of the triangulation of the State of New Hampshire.—Geodetic operations in New Hampshire were resumed by Prof. E. T. Quimby, Acting Assistant, in accordance with instructions, early in July. The first station occupied was Moore Mountain, in Brookfield, Carroll County.

Fine observing weather facilitated the progress of observations at this station; by the 4th of August all that were needed had been obtained, and in a few days more the party was ready for work on Green Mountain, in Effingham, Carroll County. Here many delays were met with, arising in part from haziness in the atmosphere, and in part from the persistent brush fires lighted by the farmers for clearing land, some of these fires creating dense smoke in lines that it was desirable to observe. These obstacles prolonged the occupation of the station until the close of September.

The remainder of the season was occupied by Professor Quimby in determining the direction of the line Whiteface-Green Mountain, and in a reconnaissance in Rockingham County, to fix upon points suitable for extending the triangulation in that direction. The statistics of the work, which was closed in October, are as follows:

Number of horizontal angles measured	67
Number of vertical angles measured	36
Number of pointings with horizontal circle	4,830
Number of pointings with vertical circle	364

Occupation of stations in continuation of the triangulation of the State of Vermont.—At Mount Equinox, in the town of Manchester, Bennington County, Vt., a station was occupied at the beginning of the season of 1883 by Prof. V. G. Barbour, Acting Assistant, in accordance with instructions directing him to continue the triangulation of the State.

This station having been previously occupied in the primary triangulation, but little cutting to open lines of sight was required, and by the 24th of July the work there was completed.

Stowell station, in the town of Rockingham, Windham County, was next occupied. For the purpose of connecting the Vermont geodetic work with that of New Hampshire, in this locality, signals were erected at Stoddard and Monadnock, and observations made upon these points, as also upon signals previously established at Croydon and Chesterfield, in New Hampshire.

Field-work was closed September 10. The statistics are:

Number of horizontal measurements	714
Number of vertical measurements	510

Examination of ledges in Lake Champlain.—Certain shoal spots having been reported by the Light-House Board as existing in Lake Champlain and not shown upon the charts, Mr. Charles Junken, Acting Assistant, was directed to proceed to Burlington, Vt., in November, 1883, and make the necessary hydrographic examinations. His report shows that both of the shoals referred to are shown upon the charts, the first one, known as "City Reef," having upon it a least depth of 4¾ feet. The second shoal was shown on the chart by the name first given to it, "Champion Rock," from the name of the vessel that struck upon it in 1863; subsequently, however, it received the name of her captain, and became locally known as "Jones Rock." Mr. Junken determined without doubt the entire identity of "Jones Rock" with "Champion Rock," and recommends that this rock, as well as "City Reef," be buoyed.

Subassistant W. Irving Vinal rendered prompt and efficient service in the work.

Reconnaissance for the introduction of additional lines in the triangulation between the Fire Island and Massachusetts and Epping base lines.—In order to strengthen the connection in the primary triangulation between the Fire Island base and the Massachusetts and Epping bases, Assistant Charles O. Boutelle was instructed to make the arrangements necessary for a reconnaissance from certain primary stations in Massachusetts and Connecticut, with a view to determine the intervisibility of the points proposed for occupation.

Under his direction Mr. J. B. Boutelle, extra observer, visited Wachusett Mountain, Princeton, Mass., and Bald Hill in Suffield, Conn. The lines that it was desirable to obtain were Wachusett–Greylock, Bald Hill–Greylock, and Bald Hill–Bald Peak. At Wachusett the summit of Greylock, near the northwestern part of the State, and distant about sixty-eight miles, was found to be distinctly visible. From Bald Hill both Greylock and Bald Peak, the latter in the southwestern part of Massachusetts, are visible. The introduction of these lines into the triangulation, in connection with those from Ivy Hill in Connecticut and from Bald Peak to Greylock, will materially strengthen it.

The reconnaissance intrusted to him having been satisfactorily completed, Mr. J. B. Boutelle transmitted to the office the records of the work.

Hydrographic examinations in Vineyard Sound and resurvey of Monomoy Passage, Nantucket Shoals.—The hydrographic examinations and resurveys required in Vineyard Sound, Monomoy Passage, and on Nantucket Shoals, in order to obtain data for correcting the published charts, were executed during the summer of 1883 by the party on the steamer Blake, under command of Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey.

Leaving New York on the 11th of July, Lieutenant-Commander Brownson anchored on the following day inside of Cuttyhunk Island, at the western entrance to Vineyard Sound, for the purpose of making an examination of certain rocks, reported as at that time not properly shown on the charts. Two rocks were determined in position, one of these being Whale Rock, which is bare at half tide, and readily seen at any time by the discoloration of the water; the other a pinnacle, with eight and a half feet at low water. Both of these rocks have been placed upon the charts.

A detached shoal having been reported as existing at the western end of L'Homme Dieu Shoal, Vineyard Sound, the examinations made by Lieutenant-Commander Brownson indicated a very decided change in the western end of the shoal, it having worn away and a hook having formed to the southward; hence the detached shoal given on Eldridge's chart is simply an extension of L'Homme Dieu.

The examinations in Vineyard Sound having been finished, Lieutenant-Commander Brownson started for Monomoy, stopping at Hyannisport on the way to locate a rock in New Harbor, to the westward of Hyannisport, Mass.

On the 18th of July was begun the principal work of the season, the resurvey of Monomoy Passage, Mass. Finding by experiment that at Powder Hole, Monomoy Point, where it had been at first intended to erect a tide-gauge, the ebb and flow of the tide was too much impeded by the narrow entrance, a gauge was established on the wharf at Harwich Port, Mass., and a companion gauge was kept for a suitable time outside near Monomoy Point.

Lieutenant-Commander Brownson states that his work shows a gradual filling in of the channel between Pollock Rip and Broken-Part-Pollock Rip; that the average depth of water over the shoals

to the westward of this channel seems to be increasing, thus restoring the equilibrium, and that he thinks it not at all improbable that in the course of a few years this channel will be useless to vessels of heavy draught. That part of the channel to the eastward of Pollock Rip light-ship, formerly much used by ships of heavy draught passing in and out of Vineyard Sound, is now shut off by a bar running nearly across it, with seventeen feet at mean low water. Should this shoaling continue so as to shut off these two channels for heavy-draught vessels, there still remains the main channel between Great Point, Nantucket, and the Stone Horse Shoal. An extended examination of this locality showed that a channel of twenty-four feet can easily be buoyed out. This new channel would increase the distance of vessels bound around the cape about eleven miles, and would be another point in favor of constructing a Cape Cod canal.

Several dangerous shoals having been developed by Lieutenant-Commander Brownson's survey between Shovelful light-vessel and Pollock Rip light-vessel, consisting of patches with a least depth of thirteen and a half feet near the northern extremity, and forming an extension of Stone Horse Shoal in a northerly direction, a "Notice to Mariners" (No. 45) was issued from the office giving directions for avoiding them.

A shoal having been reported west-southwest of South Shoal light-ship, three separate attempts were made to find it, all of which were unsuccessful. This result, together with the testimony of the keeper of the light-ship, that for ten years he had seen vessels of heavy draught passing over the supposed locality of the shoal, led Lieutenant-Commander Brownson to the belief that it does not exist. The report may have arisen from the fact that in very heavy weather the sea breaks all along from northeast to southwest of the light-ship in from six to eight fathoms.

Upon the completion of this work instructions were received to locate a rocky ledge, reported by Lieut. W. W. Gilpatrick, U. S. N., as lying off Warren's Point, R. I. This was done on the 26th of September. The ledge was found to be of small extent, with a least depth of thirteen feet, dropping off suddenly, in less than a boat's length, to four fathoms, and to six fathoms only a few yards away. Bearings and distances to prominent objects were taken from the rock, and a "Notice to Mariners" (No. 40) was promptly issued from the office. This rock, known locally as Elisha's Ledge, has since been buoyed.

The statistics of work to the date of this examination are given in Lieutenant-Commander Brownson's report as follows:

Miles run in sounding	1,000
Angles measured	5,708
Number of soundings	21,955

During an enforced absence for about a month of the chief of the party from ill-health, Lieut. F. H. Crosby, U. S. N., Assistant, was in charge of the work, and conducted its operations with much zeal and judgment. Other officers in service on the Blake were Ensigns J. T. Newton, H. S. Knapp, E. Simpson, jr., and M. C. Gorgas, U. S. N.

Subsequent work accomplished in Long Island Sound and East River, N. Y., by Lieutenant-Commander Brownson will be referred to under the heading of Section II.

Survey of Gay Head Cliffs to fix position of wrecked steamer.—Questions arising out of the events attending the wreck of the steamer City of Columbus off Gay Head Cliffs in January, 1884, especially those relating to the position of the buoy near where the steamer struck, led to the detail of Assistant H. L. Whiting to make a resurvey of the immediate vicinity of the disaster for the purpose of determining the position of the wreck, the buoys in the vicinity, and the location of as many objects on shore as might ultimately serve for a close hydrographic survey.

The positions of the wreck, of the temporary buoy established near it, of the black buoy, and the line of the beach at high water were marked by Mr. Whiting on the original topographic sheet, which was transmitted to him for that purpose.

With regard to that dangerous reef known as the "Devil's Bridge," Mr. Whiting observes that it is a bed of bowlders only. There is probably no ledge under any part of the island, or near it. These bowlders were probably on the surface of the Tertiary formation of which Gay Head is composed, and as the earthy material has been washed away, these bowlders have remained within the area of the original headland.

In many cases of single steep hills on the island, the fact is illustrated that larger bowlders and larger numbers of them have been originally deposited or have rolled down around the base of these hills than have remained on the sides or summits, and it may be found that a larger bed of bowlders exists around what was the original base or outline of this headland, if it was a single hill, than are distributed over its general area.

During a portion of the year Assistant Whiting was occupied with duties pertaining to his special assignment as a member of the Board of Harbor and Land Commissioners of Massachusetts.

Tidal observations at Providence, R. I.—The self-registering tide-gauge loaned by the Coast and Geodetic Survey in 1872 to the engineers engaged on the improvements of the city of Providence, R. I., is still retained by them. From the records for the earlier years which were transmitted to this office good results were obtained, and more valuable ones may be expected when the complete series is available for discussion.

Tidal observations at Block Island.—In January, 1884, the series of tidal observations with the self-registering tide-gauge established on the breakwater at the eastern end of Block Island was suddenly brought to a close by the tide-house and gauge being crushed by a vessel. The records from this gauge had been continuous for nearly a year and a half. Staff observations were made by the observer, Mr. J. M. Conley, for a few days to complete the last half year. This station had been made the base in the tidal surveys of Buzzard's Bay, Narragansett Bay, and Long Island Sound, and observations may be resumed if found necessary in completing the resurvey of the Sound.

SECTION II.

CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING COAST, BAYS, AND RIVERS. (SKETCHES Nos. 1, 3, AND 4.)

Topographic resurveys of Stonington, Conn., and vicinity; also of the coast of Connecticut in the vicinity of Saybrook and Lyme.—Having received instructions to resume the topographic resurvey of Stonington, Conn., and vicinity, Subassistant W. C. Hodgkins took the field immediately after July 1, 1883. In the course of the next six weeks the detailed survey was extended to include the shores of Little Narragansett Bay, lying between Stonington and Watch Hill, and also Wequetecock Cove and the mouth of Pawcatuck River. Additional shore-line was surveyed in Stonington Harbor and in Quiambaug Cove, above the railroad bridges. The borough of Stonington and village of Noank were surveyed in detail, as also the collection of hotels and dependent buildings at Watch Hill, a popular watering place, located on a cluster of sharply rounded hillocks just at the junction of the long curving sand-spit called Napatree Point.

The work in this vicinity embraces portions of the States of Connecticut and Rhode Island, the boundary between these two States following the channel of the Pawcatuck River.

By the middle of August the survey in this locality was completed within the limits assigned, and the party was transferred to Lyme, Conn., to take up the resurvey of the mouth of the Connecticut River. East of the Connecticut the work extended along the north shore of Long Island Sound from Four-Mile River to Blackhall Point and thence northward to Calves Island, the belt of topography averaging six hundred meters in width. West of the river, Cornfield Point was included in the work as well as the shore beyond, with Oyster River and the intervening creeks. On the banks of the Connecticut itself the shore-line of all creeks and coves was surveyed, as far as they were unobstructed by bridges, the work on the west side of the river extending as far north as Ferry Point.

In some cases, owing to the formation of the land, the width of this surveyed area was increased beyond the six hundred meters adopted as a standard. The alluvial marshy islands in the estuary of the Connecticut were completely surveyed. Within the limits of the sheet the towns of Lyme and Saybrook were included.

Work was closed for the season November 15. Mr. J. H. Turner, Acting Aid, joined the party on August 1 and rendered efficient service until his detachment early in November.

In May, 1884, Subassistant Hodgkins was instructed to resume work on his topographical sheet of 1883 to complete the survey of Saybrook and Lyme, and the unsurveyed portions of shore-line. In this duty he was occupied at the close of the fiscal year.

During the winter of 1883–'84, Mr. Hodgkins was assigned to service which will be referred to under the head of Section VIII.

Hydrographic resurveys of Fisher's Island Sound, and its adjacent waters continued.— Mention was made in my last annual report of the resumption of the survey of Stonington Harbor by the party in the schooner Palinurus, under the command of Lieut. A. V. Wadhams, U. S. N., Assistant Coast and Geodetic Survey. Statistics of the progress made up to June 30, 1883, were then given. During the season ending in November, 1883, the hydrography of Stonington Harbor was finished, also that of Fisher's Island Sound and Little Narragansett Bay.

To obtain a plane of reference for the soundings, a principal tide-station was established at the fish-market wharf in Stonington Harbor, and subsidiary stations at the steamboat wharf at Watch Hill, in Little Narragansett Bay; at Fox's Wharf, in West Harbor, Fisher's Island, and at the North Dumpling light-house. With the aid of these subsidiary tidal stations a good plane of reference was obtained for all parts of the work.

With reference to Stonington Harbor, Lieutenant Wadhams remarks that it is chiefly important as the terminus of the Stonington line of steamers from New York, and as furnishing a safe anchorage for vessels bound to the eastward. It has been greatly improved by the breakwaters lately built, which furnish a complete protection from the southeast gales. Navigators would be much aided in seeking a harbor if bug lights were placed, one on the west end of the eastern breakwater, the other on the east end of the western breakwater.

Little Narragansett Bay, Lieutenant Wadhams states, is full of shoals and unimportant for commercial purposes, except as furnishing a means of communication with Westerly, R. I., on the Pawcatuck River. For this purpose a channel has been dredged on the east side of the bay to the mouth of the river.

Three stations were occupied during the progress of the survey for observations of currents, one at the eastern entrance of Fisher's Island Sound, off Watch Hill Point, one on board the Eel Grass light-ship, and one at the western entrance of the sound north of Dumpling light. At each of these stations observations were continued during one flood and one ebb tide.

Lieutenant Wadhams expresses himself as under obligations to the Hon. Richard A. Wheeler, of Stonington, for information furnished in regard to the names of islands, coves, &c.

Among the most important results of the work was the development of several dangerous ledges in Fisher's Island Sound; the first off Napatree Point, the second to the northeast of Seal Rocks, and the third north of the Middle Clump. The least depths on these ledges were found to be fifteen, thirteen, and seventeen feet, respectively. A "Notice to Mariners" (No. 47) was published by the office giving the exact location of these ledges and their bearings from prominent objects.

The following-named officers were attached to the Palinurus: Ensigns T. D. Griffin, A. L. Hall, and W. C. Canfield, U. S. N.

On November 23 the Palinurus left New London for New York, where she was laid up for the winter. The statistics of the season are as follows:

Miles run in sounding	780
Angles measured	10,949
Number of soundings	42,102

Hydrographic surveys of the eastern part of Long Island Sound, and a portion of Block Island Sound.—The work assigned to the hydrographic party under charge of Lieut. John T. Sullivan, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Endeavor, comprised the resurvey of the eastern part of Long Island Sound from Race Rock to Inlet Point, and thence to Old Landing, Long Island, and additional soundings in Block Island Sound from Phelps' Ledge to Southwest Ledge. The inshore hydrography included the islands in the Race and the north shore of Long Island within the limit named. Connecting with this work, lines of soundings were run across the sound at intervals ranging from a quarter of a mile to a mile, far enough in to connect with the inshore work of other parties.

At the outset of the season, in July, 1883, tide-gauges were established at Little Gull Island, off Truman's Beach, Long Island, and in the vicinity of Nattituck Inlet, Long Island. Much difficulty was experienced in maintaining the two gauges last named on account of the exposed char-

acter of the Long Island shore and the prevalence of northerly winds. The plane of mean low water as established by the above gauges is practically that at New London.

Valiant Shoal and Rock in "The Race" were fully developed, and the search for Constellation Rock to the southward of Great Gull Island resulted successfully. Breese Rock, reported as lying about half a mile south of Constellation Rock, could not be found.

Lieutenant Sullivan's work is complete as far westward as the meridian passing clear of Goose Island, to the westward of Falkner's Island. It is plotted on three hydrographic sheets and one tracing; the former on scales of 1–20000 and 1–40000, embracing the surveys in Long Island Sound; the latter, on a scale of 1–40000, shows the soundings made in Block Island Sound.

The officers attached to the party were Lieut. W. G. Cutler, U. S. N., and Ensigns E. N. Fisher and J. P. Parker, U. S. N. Upon the close of the season in November the Endeavor proceeded to New York. Statistics of the hydrographic work, as presented in the report of Lieutenant Sullivan, are:

Miles run in sounding	912
Angles measured	8,428
Number of soundings	25,849

Hydrographic work off Shagwong Point, Montauk; resurvey of Black Rock Harbor, Conn.; examinations for rocks and ledges in East River, N. Y.—The hydrography executed by the party in the steamer Blake, under the command of Lieut. Commander W. H. Brownson, U. S. N., Assistant Coast and Geodetic Survey, during the first three months of the fiscal year, has been referred to under the heading of Section I.

Towards the close of September, after completing his work at Warren's Point, R. I., Lieutenant-Commander Brownson was instructed to place a buoy and sinker on a pinnacle rock off Shagwong Point, Montauk. This rock had been located by Assistant Gershom Bradford. The depth of water on the pinnacle having been accurately ascertained, the obstruction buoy was placed near the rock.

On the 6th of October, the Blake proceeded to Black Rock, Conn., where a hydrographic resurvey of the harbor was begun, the work being carried well up the small entrances so as to give sufficient data for determining whether certain proposed improvements were practicable or desirable. Being favored with fine weather, the survey was pushed rapidly, and finished on the 12th of October.

Information having been received from Mr. John Lockwood, Hell Gate pilot, of the existence of shoal water in the East River, N. Y., in the vicinity of Riker's Island, Lieutenant-Commander Brownson was directed to make an examination of that locality. He found a shoal of small extent, having eighteen feet upon it at low water, in the middle of the channel between Riker's Island and Legget's Point; also another rock with but seventeen feet over it in the bight between Port Morris and Legget's Point.

Navigators were promptly warned of these dangers in "Notice to Mariners No. 42," the bearings of each shoal spot to prominent objects being given.

As already stated in noticing the earlier work of the season, the officers attached to the party were Lieut. F. H. Crosby, U. S. N. Assistant, and Ensigns J. T. Newton, H. S. Knapp, E. Simpson, jr., and M. C. Gorgas, U. S. N. The statistics of the work in this section are:

Miles run in sounding	91
Angles measured	786
Number of soundings	7,709

In December the Blake was taken to Baltimore to be fitted with new boilers.

Topographic and hydrographic resurveys in the vicinity of Montauk Point, Gardiner's Bay and Orient Harbor, Long Island; also completion of hydrography between Stepping Stones light-house and College Point, East River.—At the beginning of the fiscal year, Assistant Charles Hosmer, in charge of the party on the schooner Scoresby, having executed certain resurveys in the western part of Long Island Sound, as mentioned in my last annual report, transferred his party to the vicinity of Greenport, Long Island.

During the summer and autumn, topographic resurveys were made of Montauk Point, and of Shelter, Gardiner's, Plum, and Gull Islands. Also of Orient Harbor and vicinity. Hydrographic work was done in the northern part of Shelter Island Sound, and in Long Island Sound, to the north of Montauk Point.

Leaving a topographic party to finish the work at Orient Point, Assistant Hosmer proceeded in the Scoresby about the 10th of October to the western part of the Sound to complete the hydrography between Stepping Stones light-house and College Point, East River.

All of the hydrography laid out for the party having been finished by the middle of November, and the season being too far advanced to continue topographic work to advantage, field operations were then closed.

Assistant Hosmer expresses his high appreciation of the services of Ensigns R. P. Schwerin, and D. P. Menefee, U. S. N., who were attached to his party. The statistics of work accomplished are:

Number of angles measured in triangulation	51
Number of points determined	5
Number of miles of shore-line surveyed including low water line and creeks	205
Miles of roads surveyed	31
Area surveyed in square miles	13
Miles run in sounding	486
Angles measured	4,722
Number of soundings	38,044

Under the head of Section VIII reference is made to duty subsequently assigned to Assistant Hosmer on the coast of the Gulf of Mexico.

Completion of observations with self-registering tide-gauge at Fort Trumbull, New London, Conn.—The observations at Fort Trumbull, New London, Conn., with a self-registering tide-gauge which had been established there early in October, 1882, were brought to a close November 20, 1883, a fine record for somewhat more than a year having been secured by the care of the observer, Sergeant F. Koch, stationed at the fort.

This gauge was established on account of its utility in the resurvey of Long Island Sound; it will yield also improved data for use hereafter in predicting the tides, New London having been selected as one of the principal ports to which the tides of neighboring ports are referred in the tide tables published annually by this office.

Topographic resurveys of the north shore of Long Island Sound, between New London and Four-Mile River, and between Saybrook and Clinton.—In continuation of the topographic resurvey of the shores of Long Island Sound, Assistant W. H. Dennis, in July, 1883, took up the detailed topography upon the sheet of New London and vicinity, the shore-line and part of the details upon which had been done during the previous season. Mr. Dennis completed a margin of topography upwards of four hundred meters in width upon this sheet, and then began work upon the next sheet westward, which included the shores of Niantic Bay and Four-Mile River. Having carried the topography upon this sheet from one-fourth to one-half a mile inward, and finished it September 25, the party was moved to Clinton and work begun from Saybrook westward. Details of shore topography to the same extent inland as on the previous sheet having been completed to include the shores of Killingworth Harbor, west of Kelsey's Point, in the town of Clinton, and the next sheet westward, at the town of Madison, having been begun, the field season was closed November 28.

Assistant Dennis acknowledges in his report the thoroughly competent and efficient service rendered in his party by E. L. Taney, Aid. The statistics are:

Miles of shore-line surveyed	69
Miles of roads	105
Miles of creeks	25
Miles of marsh-line	35
Area surveyed in square miles	25

Hydrographic resurvey along the north shore of Long Island Sound between Goshen Point and Hammonassett Point.—Having organized his hydrographic party on board the schooner Silliman, Lieut. John D. Keeler, U. S. N., Assistant Coast and Geodetic Survey, left New York and arrived at New London, Conn., early in July, 1883. The work intrusted to his charge was a hydrographic resurvey of the shoal water along the north shore of Long Island Sound, beginning at Goshen Point, one-half mile west of New London Light, and extending to Hammonassett Point at the western entrance of Clinton (or Killingworth) Harbor.

At the outset of operations an arrangement was made with Lieut. John T. Sullivan, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Endeavor, with regard to the limits of work to be done by each party, Lieutenant Sullivan's lines of soundings across the Sound being carried far enough in to connect with the inshore work.

Tide-gauges were established at Millstone Point, Fenwick Wharf, and, as the work progressed, at Duck Island Harbor, the last-named gauge being observed for reference only, while the observations at the two first-named ones were continuous for at least a lunar month.

The several reefs and shoals included within the limits of the survey were thoroughly examined. Among them were Bartlett's Reef, Two Tree Island Shoal, the small shoal off Hatchett's Point, the shoals off the mouth of the Connecticut River, Long Sand Shoal, the shoal off Cornfield Point, the Hen and Chickens, and Crane Reef.

On Bartlett's Reef no new dangers were discovered, but a group of rocks just to the eastward of it, known locally as "The Triangle," or "Triangle Rocks," was successfully searched for and located.

While working to the southwest of Black Point, a shoal sounding was taken in four fathoms; this locality was afterwards examined, but nothing shoaler than this was developed.

The extensive shoals off the mouth of the Connecticut River were developed with great care. Lieutenant Keeler calls attention to the fact that these shoals are changing the character of their surface constantly, and almost with every shift of wind; certainly so when the wind blows with violence.

With regard to the Connecticut River, he observes that the usual entrance through the jetties can be used in almost any weather, but that after passing Saybrook light there is nothing to mark the channel, which is quite narrow, although the river is wide. On the eastern side of the channel there are several sunken stone piers, covered at half tide, and the strong current running makes it difficult for a stranger to proceed up the river with confidence. Lieutenant Keeler recommends that the channel be buoyed. With his report he has submitted a tabular statement of the number of vessels of all kinds passing in and out of the Connecticut from September 8 to 30, inclusive. The whole number is four hundred and twenty-nine, an average of about nineteen a day.

While surveying Westbrook Harbor two rocks were discovered which had not been marked on the charts; their positions were carefully determined by bearings and otherwise.

Lieutenant Keeler's report, of which an abstract only is here given, is exceedingly full and complete in its detailed statements respecting the localities included in his survey. He expresses his gratification with the spirit manifested by the officers who assisted him in conducting the work. These were Ensigns F. H. Sherman, C. W. Jungen, and T. C. Dewey, U. S. N.

The statistics of the season, which closed early in November, are:

Miles run in sounding	750
Angles measured	11,630
Number of soundings	44,146

During the winter the Silliman was laid up in New York, in charge of Ensign Sherman.

Information having been received at this office from the Old Colony Steamboat Company of the existence of a dangerous rock in East River, Ensign Sherman was directed to examine the locality. He found a pinnacle rock not over four yards square, and situated one hundred and fifty yards outside of Nes Rock, and on the prolongation of Twentieth street, New York City. The least water found over the rock was twelve and a half feet. A "Notice to Mariners" (No. 48), giving exact location and bearings, was immediately published, and information having been furnished to the

Light-House Board, they caused a danger buoy to be placed on the rock May 28. This buoy may be passed on either hand.

In the search for the rock Ensign Sherman had the aid of Ensign W. C. Canfield, U. S. N.

Topographic resurvey of the north shore of Long Island Sound from Bridgeport to Farms (or Frost's) Point.—Assistant E. Hergesheimer, under instructions issued in June, 1883, reached the field July 1, and began a topographic resurvey of the north shore of Long Island Sound from Bridgeport westward to Farms (or Frost's) Point.

Between these limits the belt of topography surveyed extended on the average seven-eighths of a mile from the coast. The topographic sheet included the city of Bridgeport, the solid interior of which was compiled from the records of the city survey department, furnished by H. G. Scofield, city engineer.

Field operations closed October 25. The exceedingly skillful and artistic delineation of details of topography and lettering on the field sheet, as brought out distinctly in the inking, led to its reproduction by the photolithographic process without reduction from the original scale of survey (1-10000), and with marked success.

Following are the statistics:

Miles of shore-line surveyed, including shore-line of rivers, creeks, and ponds...	59
Miles of roads	57
Area surveyed in square miles	9

Re-establishment of points of the old triangulation and determination of additional points on the south shore of Long Island Sound, between Horton's Point and Old Field Point.—In order to furnish points for the resurvey of Long Island Sound, Assistant S. C. McCorkle was specially charged with the recovery of the old stations between Horton's Point and Old Fields Point on the north coast of Long Island, and with the determination of such additional points as might amply suffice for the uses of the topographic and hydrographic surveys.

In pursuance of this duty, after having selected as a base the line Osborn-Shinnecock, Mr. McCorkle was fortunate in identifying seven stations of the former triangulation. His reconnaissance and subsequent occupation of stations in the scheme laid out, between the limits just referred to, provided all the points needed in the progress of the survey on that coast. His report states in detail the characteristics of the country passed over.

The statistics of the work, which closed November 30, are as follows:

Number of stations occupied	27
Number of angles measured	225
Number of observations made	2,064
Number of positions determined	38

It was deemed desirable to mark permanently the station on Shinnecock Hills, and, in accordance with arrangements made to that effect with Mr. Austin Corbin, the owner of the land on which the station is located, Assistant McCorkle, in May, 1884, placed a granite pillar over the iron cone beneath the surface which had been secured in position as an underground mark by Assistant J. A. Sullivan in 1874. The surface marks placed by Assistant F. H. Gerdes in 1879 were found to be in good order.

Supplementary triangulation between Eaton's Point and Sands' Point, north coast of Long Island, and of the opposite shore, for the resurvey of Long Island Sound.—The duty of executing the supplementary triangulation of the shores of Long Island Sound, from Eaton's Point to Sands' Point and opposite, was committed to Assistant Gershom Bradford by instructions issued early in August, 1883.

Having organized his party, and established his headquarters at Northport, L. I., as a central point, Mr. Bradford pushed the triangulation across the Sound to the westward from the lines Eaton's Point-Copp's Island, and Eaton's Point-Chimon's Island.

At the close of the season, December 13, the triangulation finished included the country about Huntington Bay and Northport Bay, reaching westward on the Long Island shore to Oak Neck

Point and to stations on the Connecticut shore; these in turn connecting with the triangulation of Mr. Bradford's previous season in Connecticut.

During the winter Mr. Bradford was engaged in office-work pertaining to his field operations, and in a special investigation relating to the several methods of reading the mariner's compass. On this subject he made a detailed report.

Towards the end of May he was directed to resume the triangulation of Long Island Sound, and to connect it with the original primary stations Bald Hill and Round Hill. Provisional stations had been established near those points by Mr. Bradford in 1882, but as the work progressed it became desirable to refer it to the original line. By applying azimuths and distances from the approximate positions of 1882, the station marks left by Assistant Edmund Blunt in 1866 were recovered with but little digging. The old station, Eaton, on Eaton's Neck, was recovered also.

At the close of the fiscal year 1883-1884 the triangulation was in active progress. Statistics of the work to that date are:

Number of stations occupied	16
Number of pointings made	3,897
Geographical positions determined	13

Completion of the primary triangulation across the State of New York for connecting the triangulation of the Hudson River and Lake Champlain with that of the survey of the Great Lakes.—At the beginning of the fiscal year, as mentioned in my last annual report, the party of Assistant Charles O. Boutelle was about to occupy Howlett Station, about 9 miles west of Syracuse, a point identical with the State survey station of that name, and one of the last in the scheme for connecting the survey of Hudson River and Lake Champlain with that of the Great Lakes by a primary triangulation across the State of New York.

Early in July, 1883, the observing tripod and scaffold of the State survey at Howlett was rebuilt and occupied at an elevation of about 50 feet for the measurement of horizontal directions. The usual observations for latitude and azimuth were made by Mr. J. B. Boutelle, extra observer, and Prof. L. L. Barnard, of State College, Pennsylvania, who was temporarily attached as Acting Assistant to the party. Local time was determined by Subassistant J. B. Baylor, who also made the observations for magnetic declination and intensity.

Twenty inch theodolite No. 113 was used for the measurements of horizontal directions. Twenty-four pairs of stars were observed for latitude with zenith telescope No. 5. For local time the new prismatic transit was used for the first time in the field. Assistant Boutelle reports favorably upon this instrument as both accurate and exceedingly convenient for field observations.

At this station, as at all others of the primary chain, vertical angles were carefully observed.

Upon the close of observations at Howlett's station, Professor Barnard was detached from the party, and Subassistant Baylor was directed to occupy the station of the Lake Survey, Clyde, in Wayne County, for the determination of horizontal directions, vertical angles, and magnetic declination and intensity. While this work was in progress, Assistant Boutelle proceeded to Oswego to occupy the Lake Survey station of that name in the southwestern part of the city. A tripod one hundred and nine feet high had been built here by the United States Engineers in 1874. Finding it much decayed, repairs were about to be begun, when by a furious gale which swept over Lake Ontario, the whole structure was blown to the ground. A new observing tripod and scaffold, forty-six feet high, was at once begun, and finished in five days, being in readiness for occupation October 1. Subassistant Baylor was at this date detached from the party. Observations of horizontal and vertical angles were finished October 16. A double line of levels was run from the Lake Survey station "Oswego" to their bench-mark close to the shore of Lake Ontario. This bench-mark had been previously connected by the Lake Survey parties with the Coast and Geodetic Survey bench-mark at Greenbush on the Hudson, opposite Albany, by a double line of levels.

The Lake Survey station "Victory," about seventeen miles in a southwesterly direction from Oswego, was next occupied. The tripod originally built at the station was found to be in good order, and the twenty-inch theodolite was mounted upon it October 18, with the telescope at an elevation of over ninety feet. The observations of horizontal and vertical angles at this station

were made by Mr. J. B. Boutelle, and upon their completion, October 30, field operations were closed for the season.

In order to establish a thorough connection between the Coast and Geodetic Survey and Lake Survey systems of triangulation, Mr. J. B. Boutelle was instructed to proceed to Mannsville, N. Y., in May, 1884, and under the direction of Assistant Boutelle, to occupy the Lake Survey station of that name for the purpose of measuring the angles between stations Loomis, Oswego, and North base. By these observations a direct connection was obtained with the Sandy Creek base of the Lake Survey. This work, including a determination of the magnetic declination and intensity, was completed on the 18th of June.

A report upon the results of Assistant Boutelle's triangulation across the State of New York, and its connection with the triangulation of the Lake Survey will be found in Appendix No. 9. These results verify the indications referred to in my last annual report as derived from the preliminary computations, and show that a close and satisfactory agreement has been reached at the junction of the two systems of triangulation, "an agreement which is the more satisfactory, since each system is an absolutely independent work, starting from bases widely separated on the Atlantic coast and on the Great Lakes, and carried on by independent methods, instruments, and observers."

After closing work at Mannsville, Mr. J. B. Boutelle was directed to visit Kingston, Canada, to make inquiry respecting the possible use of an astronomical station in the grounds of Queen's College and University as the north end of the Pamplico arc of the meridian. This service, as well as other duty already referred to under the head of Section I, was executed with skill and diligence. Mr. Boutelle's report has been transmitted to the office.

Hydrographic resurvey of the approaches to New York.—In accordance with instructions issued in June, 1883, Lieut. H. B. Mansfield, U. S. N., Assistant Coast and Geodetic Survey, organized a hydrographic party on the steamer A. D. Bache for the resurvey of the approaches to New York.

About the 15th of July, all preparations having been completed, the work was begun. As far south as latitude 40° 12′ north, and as far east as longitude 73° 23′ west from Greenwich, lines were run from both the New Jersey and the Long Island shores a quarter of a mile apart to the five fathom curve; a half a mile apart to the ten fathom curve, and to the limits of the sheet, the curves of fifteen and twenty fathoms, a mile apart. Additional lines were run normal to the New Jersey coast and two miles apart as far south as the head of Barnegat Bay to connect this work with that of Lieutenant-Commander Brownson in the steamer Blake.

The weather upon the whole was not favorable for offshore work, but by taking advantage of every favorable opportunity, the resurvey was completed October 11.

Close lines of soundings were run over the locality known as the "Cholera Bank," but no depths were found of less than ten to eleven fathoms.

Lieutenant Mansfield observes that the most interesting result of the resurvey appears to be the development of the so called "holes" in the approaches to New York entrance into a clearly-defined gully, easily traced from the outer limit of the work to the vicinity of the Sandy Hook light-vessel. There are great differences in depths of water in this gully, but its bottom in every part consists of blue clay and fine sand, characteristics found nowhere else within the limits of the survey, thus reducing all sailing directions for the light-vessel in thick or foggy weather to the simple use of the armed lead.

All soundings were referred to the datum plane of the permanent tide-gauge at Sandy Hook.

Acknowledgment is made by Lieutenant Mansfield of the cheerful assistance rendered in the work and the good judgment shown in its conduct by the officers attached to the Bache—Ensigns W. B. Caperton, J. M. Orchard, C. S. McClain, and Harry Phelps, U. S. N. The statistics are:

Miles run in sounding	1,094
Angles measured	1,969
Number of soundings	8,029

Specimens of bottom were taken at every position occupied.

Early in the winter Lieutenant Mansfield was instructed to fit the Bache for work on the west

coast of Florida. Duty assigned to him on that coast will be referred to under the head of Section VI.

Observations of currents and other hydrographic work off New York entrance.—The work assigned to Lieut. J. C. Fremont, U. S. N., Assistant Coast and Geodetic Survey, by instructions dated early in July, 1883, was to make observations for currents at stations near the one hundred fathom curve between Montauk Point and Cape May, and upon the completion of these observations to take up the examination of certain localities of shoal soundings off New York entrance.

Having organized his party on board the schooner Drift, Lieutenant Fremont left New York July 16, and after having occupied ten current stations returned to New York October 10. All along the one hundred fathom curve the same currents were found, the current swinging the vessel with the sun with great regularity. To this regular swinging with the sun the exceptions were at stations 9 and 10, near to or in the gully leading out of New York Harbor. At both of these stations the observations showed the current to run alternately about northwest and southeast. There was also an absence of the usual tide rips.

The remainder of the season was occupied in soundings off Sandy Hook, off the New Jersey coast, and in Gedney's Channel, New York entrance. Special examinations were made in and around the Oil Spot, the outer Middle Ground, and around the obstruction buoy which is over the eighteen-foot spot between the whistling buoy and the second mid-channel buoy of the South Channel; also around buoy No. 3, and the second mid-channel buoy of Gedney's Channel.

Lieutenant Fremont had the aid of Ensigns A. F. Fechteler, F. W. Kellogg, and F. R. Brainard, U. S. N.

The Drift returned to port November 17, and during the winter was fitted for a cruise in the Gulf Stream. Reference will be made to Lieutenant Fremont's observations of currents of the east coast of Florida under the head of Section VI.

Continuation of series of tidal observations with self-registering tide-gauge at Sandy Hook, N. J.—For the last two years the self-registering tide-gauge at Sandy Hook, N. J., has been in charge of F. W. Shepheard. The gauge is now located close beside the station office of the New Jersey Southern Railroad, at the north end of the bight known as "The Horseshoe" in Sandy Hook Bay. Some interruption of the observations has occurred during the year by reason of extensive repairs that have been made to the wharf, and in the winter by the ice which is forced across the bay and congeals in thick masses near the float-box. New piles have been driven and heavy braces arranged about the float-box so that hereafter it will be better protected. There is ample depth of water at the gauge.

Triangulation of the northern part of the State of New Jersey continued, and reconnaissance begun for the extension of the triangulation in the southern part.—Geodetic operations in the State of New Jersey have been continued as heretofore by Prof. E. A. Bowser, Acting Assistant.

Field-work was begun June 1, 1883, by the occupation of station High Mount, about 5 miles north of Paterson, Passaic County. Signals were erected at Mount Horeb, Mount Olive, Bald Hill, Bear Fort, High Torne, Weasel, and Buttermilk Hill; at the two latter stations in order to form a direct connection between the New Jersey triangulation and the primary triangulation of the coast. At Mount Horeb, 35 miles southwesterly from High Mount, a heliotroper was established.

Observations were completed at Mount Horeb August 11, and the party was then moved to station High Torne, near Ramapo, in Rockland County, N. Y. The signals Bald Hill, Bear Fort, Buttermilk Hill, and Weasel were readjusted, and a signal erected at High Mount. A vista was opened through the woods on Ramapo Mount, two miles east of High Torne, to render visible the station on Buttermilk Hill. Work at High Torne having been finished October 4, Professor Bowser made preparations for resuming the reconnaissance in the southern part of the State. Five stations had been selected before the beginning of the fiscal year, starting with the line Ridgeway-Applepie Hill. Continuing the exploration of the country to the southward and westward, four additional stations were selected, though not without much difficulty, the country being flat and thickly wooded. What seemed like a ridge would not unfrequently be found to be, on a nearer inspection, a low swamp with very tall trees, while, on the other hand, the trees on some of the

ridges were so low that their tops were not visible from the station of reconnaissance. At many of the points scaffolds and tripods of forty feet in height will be needed.

Field operations were closed November 3. In the spring of 1884 Professor Bowser was authorized to resume the reconnaissance, carrying it west and southwest from Williamstown, Gloucester County.

Continuation of the triangulation and reconnaissance of the State of Pennsylvania.—Geodetic operations in the State of Pennsylvania were resumed by Prof. Mansfield Merriman, Acting Assistant, early in July, 1883. Three stations were occupied during the season for the continuation of the triangulation to the southward and westward.

From Gov. Dick, the first station occupied, about six miles south of Lebanon, Lebanon County, observations were made upon eight stations, at six of which heliotropers were posted.

On July 30, the work at Gov. Dick having been completed, Professor Merriman occupied a station at Winterstown, York County. From this point four stations were observed, and the work was finished August 7, when the party proceeded to Round Top, a station about eleven miles in a southerly direction from Harrisburg. With the occupation of Round Top, from which five other points were observed, the measurements of horizontal angles closed, and during the remainder of the season Professor Merriman visited other stations in the scheme to the westward, for the purpose of selecting positions nearly enough approximate to facilitate the final selection during the next year.

Statistics of the work are as follows:

Number of angles measured	34
Number of pointings	3,264
Stations approximately selected	3

Survey of the boundary line between the States of Pennsylvania and West Virginia.—Mention was made in my last annual report of the detail of Subassistant O. H. Sinclair to execute the work of tracing out the boundary lines between Pennsylvania and West Virginia, in compliance with a request from the Joint Commission of those two States.

Subassistant C. H. Van Orden was instructed to report for duty to Mr. Sinclair.

An understanding having been arrived at with the Joint Commissioners as to the most desirable mode of tracing and marking the meridian boundary line, the work was begun at Smith's Ferry, Beaver County, Pa., by measuring an azimuth and passing a meridian through the apex of the large granite monument that marks the south end of the boundary line between the States of Pennsylvania and Ohio.

The observations for azimuth and time were made with the ten-inch repeating theodolite No. 82, and recorded by means of a Parkinson and Frodsham sidereal chronometer. The diaphragm of this theodolite had been fitted with three vertical wires; its horizontal axis was perforated and provided with a lamp and mirror for illuminating the threads; these, with a vertical circle and diagonal eye-piece comprised the set of attachments which were removable at pleasure. This instrument was used also for ranging out the line. A 6-inch Brunner theodolite provided with telemeter wires and a vertical arc; a graduated rod, chain, and pins, a steel tape, two pocket heliotropes for ranging in points at long distances, and the necessary field-glasses completed the instrumental outfit of the party.

Mr. Sinclair's plan of operations was to secure as long lines of sight with the large theodolite as possible; to clear the line of all obstructions and locate points on the prominent hills for the use of the second party under Mr. Van Orden, who, with the 6-inch theodolite, located all the old boundary-line marks, measured the length of the line, and established in position points for the new monuments. On account of the broken character of the country, the first plan of chaining the line for distance was abandoned, and a series of small triangulations was carried on from short measured bases, this method giving the lengths required with expedition and accuracy.

At the distance of eleven miles from the initial point, as the meridian was found to diverge from the old line-stones, a check azimuth was measured and the meridian found practically perfect. Beyond this point a series of long sights was secured, ranging from three to eleven miles, and at

a point fifty-three miles and seven-tenths from the initial point another azimuth was measured, the line being found accurate as at the preceding test.

From this point to the southwest corner of Pennsylvania the distance was only ten miles, and was traversed in three sights.

The deviation of the line, as marked by the old line-marks, from the meridian line traced south from the Ohio and Pennsylvania granite monument, was rather regular to the west, and at the southwest corner of Pennsylvania it amounted to fifty-four feet and five and a half inches.

As soon as the line had been measured and the positions of the old line marks located with respect to the meridian, the Joint Commissioners, at a meeting held July 3, adopted for the boundary a straight line through the southwest corner of Pennsylvania and the first stone south of the Ohio, placed in the meridian of the granite monument on the Ohio and Pennsylvania boundary.

Twenty-four of the old line stones were found, twenty of which were deemed authentic. From these the old line was reproduced, and it was found that the new boundary would cause a loss of but ten and four-tenths acres to West Virginia.

This boundary it was decided to have marked with large sandstone monuments.

For the longitude of Smith's Ferry, signals were exchanged on two nights in July with the longitude party at Louisville, Ky. Additional exchanges could not be obtained owing to the general strike of the telegraph operators which began July 19. Latitude was determined with the zenith telescope by sixty observations. The position of the longitude station was carefully marked, and connected with that of the boundary monument by the measurement of a base and a small scheme of triangulation.

In the following month, with my approval, Mr. Sinclair was authorized by the Joint Commissioners to trace out a portion of the boundary between Pennsylvania and West Virginia running eastward from the southwest corner of Pennsylvania along the parallel of 39° 43′.3, nearly. This boundary to the Maryland corner is about fifty-five miles in length. This distance Mr. Sinclair divided into four sections by five latitude stations, each located near some authentic mark on the old line. At each station latitude was observed with zenith telescope No. 6 on twenty-three pairs of stars on three nights, except at the initial point, the southwest corner of Pennsylvania, where observations were obtained on four nights.

These observations having been completed and the field computations made, the party assembled at the initial station September 26, to begin tracing the parallel boundary.

The method employed was to observe an azimuth, lay off an angle of ninety degrees from the meridian, and range out a tangent in the prime vertical of the initial point as a line of reference for the old boundary marks and for the positions of the new monuments. Three sections of the parallel boundary were thus traced out for a total distance of thirty-five miles and eight-tenths, when it became necessary to suspend operations for the season.

In the first twenty-one miles from the initial point towards the east there were five well-authenticated line marks, and the boundary, as reproduced from these, very nearly coincided with the theoretical parallel through the southwest corner of Pennsylvania (supposing the spheroid uniform).

The work of Mason and Dixon in 1767 terminated about twenty-one and a half miles east of the initial point. Upon reaching their boundary, the line was found to bend to the south with moderate uniformity for nearly ten miles, where it has a maximum deflection of one hundred and seventy-four and a half feet south of the theoretical curve through the southwest corner. East of this, and for a distance of nearly five miles, the boundary turns northward and is nearly a true parallel. Mason and Dixon's marks were large mounds six to eight feet in diameter, and most of them about six inches high. For twenty-one miles from the initial point towards the east the old line marks were old posts or post-holes in heaps of stones.

Twenty-one miles of the parallel boundary were ready for marking in November, 1883, but the rest of it cannot be marked until the survey has been completed to the Maryland corner, a distance of about nineteen miles. The meridian boundary was permanently marked during July and August 1883, and the meridian itself preserved by extra monuments.

Subassistant Sinclair acknowledges the very efficient aid rendered to the work by Subassistant Van Orden, who had charge of the second party and made the map of the two boundary lines.

The original maps and a full report of the work have been transmitted to the Joint Commissioners; a duplicate of the report and tracings of the maps are deposited in the Coast and Geodetic Survey archives.

Statistics of the work are as follows:

Number of miles of meridian boundary surveyed	64.1
Number of miles of parallel boundary surveyed	35.8
Number of azimuths measured on meridian boundary	3
Number of azimuths measured on parallel boundary	3
Number of observations made for azimuth	202
Number of observations made for latitude	355
Number of stations occupied for latitude	6
Number of stations occupied for longitude	1
Number of observations made for time	725

Reference will be made under the head of Section III to duty subsequently assigned to Mr. Sinclair.

Topographic survey of the New Jersey coast from Cape May Court-House northward.—Under instructions issued at the beginning of the fiscal year Assistant Charles M. Bache resumed the topographic survey of the coast of New Jersey in the vicinity of Cape May Court-House. A new barge was being constructed for the use of his party, and while awaiting its arrival Mr. Bache was occupied in locating on a former topographic sheet a newly-built railroad running from the Cape May Branch of the West Jersey Railroad to Anglesea, a seaside resort lately established on Five-Mile Beach, near Hereford Inlet.

Time was utilized also in tearing away such parts of the old barge as could be made serviceable for the new one. On the 14th of August, the new barge having arrived and certain needful additions having been made, the party proceeded to the locality of work, and by the middle of October, when field-work was closed, had carried the topography from Cape May Court-House northward to Leaming's Sound and towards the coast at Leaming's Beach and Townsend's Inlet. High winds were very prevalent during the season, retarding the plane-table work.

Mr. W. B. Mapes served in the party as acting aid from September 1 to the close of the season. Statistics of the survey, which was on a scale of 1-20000, are:

Miles of road surveyed	7
Miles of shore-line of creeks	70
Area surveyed in square miles	13

Physical hydrography of Delaware River and Bay, and location of port-warden lines in the harbor of Philadelphia.—The attention of Assistant Henry Mitchell has been specifically directed during the past year to the study of the physical hydrography of Delaware Bay and River, although duties pertaining to membership in the Mississippi River Commission, and in other boards where he represents this Survey, have also occupied much of his time.

A great amount of data for his studies of the Delaware River and Bay have been furnished by the recent surveys, and in a carefully prepared article, published as Appendix No. 8 to my report for 1883, he discussed the laws of variation in sectional area, mean depth, mean channel depth, &c., in that portion of the stream which has been designated as "The Estuary," lying between the city of Philadelphia and the head of the submerged delta, fifty miles below.

He has since submitted a paper in which he reviews a progress report by Assistant H. L. Marindin, who is engaged upon a comparison of the new hydrographic surveys with those executed forty years ago. Mr. Mitchell's paper (not designed for publication) is a prospectus of the new study, foreshadowing probable results, and justifying the great expenditure of labor required.

The progress report of Mr. Marindin, to which reference has just been made, is published as Appendix No. 12 to this report.

It discusses the changes in the Delaware between Old Man's Point and Deep Water Point, including Cherry Island Flats, and in the bay between Reedy Island and Liston's Point. Mr. Marindin was directed to take up the comparison of these disconnected localities because of the

opportunity afforded of studying the effect of artificial changes by dredging in the channel to the west of Cherry Island Flats, and because the vicinity of Reedy Island is generally accepted as the head of Delaware Bay, and as the future locality of an ice-harbor.

With regard to Cherry Island Flats, Mr. Mitchell remarks that they are not only growing, but traveling. That the movement of the center of gravity is down stream and towards the concave (right) banks, probably in the direction of a small resultant of flood and ebb streams; and that the observations to be made to explain the existence of this bank, its growth, and its movement, so as to predict its future, would consist of current measurements in a cordon of stations during the dry season, and a gauging of the river discharges in the wet season.

An inference of value drawn by Mr. Marindin from his investigations in the same locality is that of the two rival channels around the Flats, the eastern channel would have been the better one for improvement by dredging, the comparisons showing that without any aid outside of natural forces the eastern channel has gained in depth since 1841, notwithstanding the adverse conditions of opening a rival channel by the removal of a million and a half cubic yards of material.

Mr. Marindin's assignment to duty as consulting engineer of the United States Advisory Commission on port-warden lines for the port of Philadelphia occupied him during the first half of the fiscal year. In December he returned to the suboffice in Boston, and has since been engaged continually in the party of Assistant Mitchell, in comparisons of the Delaware River hydrographic surveys. Mr. J. A. Sullivan was attached to the party during the year, and has made, under Mr. Mitchell's direction, a number of investigations requiring the most critical study and careful labor.

Topographic resurvey of the New Jersey shore of Delaware Bay continued.—Early in July, 1883, Assistant R. M. Bache organized his party for the continuation of the topographical resurvey of the New Jersey shore of Delaware Bay. His first work was to finish a topographic sheet begun the previous season, and extending from Elsingborough Point to Jacob's Creek, in the vicinity of Greenwich, N. J. Then, under instructions, he went to Cape May Point, and beginning the plane-table survey there, worked up the shore of the bay to the mouth of Goshen Creek, where, on the 15th of November, field operations were brought to a close. This part of the work is comprised in two topographic sheets, one from Cape May Point to the Hummocks (finished), and one from the Hummocks to Goshen Creek (unfinished). The scale of these sheets, as of the one previously referred to, was 1–20000.

Mr. Bache observes in his report that the mapped margin back of high-water line varies from a quarter of a mile to a mile in width, depending upon the configuration of the country, no attempt being made to go back beyond what clearly shows on the one hand the relation of the space delineated to the bay, and on the other hand to the back country; no arbitrary line, where there is no natural boundary, being able to give to a topographical margin the true suggestive significance of the country beyond. The statistics of the season are:

Miles of shore-line of Delaware Bay surveyed	21
Miles of shore-line of creeks and ponds	51
Miles of roads	26
Area surveyed in square miles	14

During the winter Assistant Bache inked, lettered, and sent to the office two topographic sheets of his survey, and towards the close of the fiscal year prepared to take the field at as early a date as the state of the appropriation would permit.

Continuation of the topographic resurvey of the western shore of Delaware Bay.—Assistant C. T. Iardella took the field for the continuation of the topographic resurvey of the western shore of Delaware Bay about the beginning of July, 1883. The two topographic sheets which he completed, on a scale of 1–20000, included a margin of topography varying from half a mile to a mile and a half in width along the shore of the bay between Bombay Hook light and Clark's Station (2), about three and a half miles north of Mispillion Creek light-house. Comparisons with the survey of 1845 showed marked changes in the shore line, many of the old triangulation marks having been washed away.

Mr. Iardella has made note of some of the leading features of the creeks surveyed in the progress of the work, as follows:

"Leipsic Creek is one hundred and eighty meters wide at its entrance. Bold water can be carried to the depth of ten feet at high tide as far as Leipsic village. The survey of 1845 connected Leipsic Creek with Old Duck Creek and Dona Creek, forming an island called Little Bombay Hook. This island has entirely disappeared, there being now nothing but marsh between Leipsic and Dona Creeks.

"Dona Creek is one hundred and twenty-three meters wide at its mouth. Bold water can be carried from the entrance to Dona Landing to the depth of from ten to fifteen feet. Vessels drawing six feet can enter at high tide; at low tide there is shoal water.

"Mahon's Ditch entrance is one hundred and fifty meters wide. Great changes have taken place in this locality within the past few years; the shore on each side of the creek has been washed away, so that the light-house is nearer the bay by forty meters than it was when first built. High spring tides surround it for about a quarter of a mile to the westward.

"Little Creek is sixty meters wide at its mouth and forty-five meters in width from its mouth to Little Creek Landing, distant in a straight line about four miles, but by the creek, which is very crooked, about nine miles. To the landing there can be carried some fifteen feet of water.

"Jones's Creek is one hundred meters wide at its entrance. Large vessels drawing seven feet can go as far as Bartlam's Landing. It is navigable for small boats from said landing to Dover."

Field-work was closed November 13. The statistics of the season are:

Miles of shore-line surveyed	41
Miles of shore-line of ponds, creeks, marsh line, and ditches	43
Miles of roads	10
Area surveyed in square miles	26

Hydrographic resurvey of Delaware Bay from Mahon's River to Mispillion Creek light.—In pursuance of instructions issued about the beginning of the fiscal year, Lieut. C. McR. Winslow, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Ready, organized a hydrographic party for continuing the resurvey of Delaware Bay.

The working ground extended from Mahon's River light to Mispillion Creek light, on the western shore of Delaware Bay, and lines of soundings were run normal to the direction of the bay and shoals, and extended across the Joe Flogger Shoal to the main ship-channel. A sufficient number of cross-lines were run to verify the soundings. On the flats between Mahon's River and Murderkill Creek, to westward of the deep holes and channels, the lines of soundings were run at a greater distance apart, as the bottom in this portion of the survey is very regular. Oysters are planted all over these flats. The shoal to northward of Cross Ledge light was also surveyed.

A plane of reference for the soundings was obtained by observations of high and low water for a month at the tide-gauge established at Mahon's River. A second gauge was erected on the beach between Mispillion Creek light-house and Murderkill Creek, and a third at Cross Ledge light-house. Comparisons were made between these gauges and the gauge at the iron pier, Lewes, Del. At the tide-gauges on Mahon's River and on the beach near Mispillion Creek light-house bench-marks were established.

Before the close of the season, November 17, one hydrographic sheet, scale 1–20000 had been completed, and another one begun. Lieutenant Winslow calls attention to the want of proper buoyage on the channel side of Joe Flogger Shoal, and remarks that additional buoys in that locality would greatly facilitate navigation. Special mention is also made in Subdivision 15 of the Atlantic Coast Pilot of this absence of buoys.

The following-named officers were attached to the party and aided in the work: Ensigns William Truxtun, John S. Watters, and Louis S. Van Duzen, U. S. N. Statistics reported are:

Miles run in sounding	346
Angles measured	3,315
Number of soundings	25,291

Topographic resurvey in the vicinity of Cape Henlopen.—Changes of shore-line produced by the action of the sea in the vicinity of Cape Henlopen rendered a speedy resurvey of that locality advisable. Assistant E. Hergesheimer was accordingly directed to proceed to Lewes, Del., in April, 1884, and to make a survey of the shore-line and adjacent topography of Cape Henlopen from the ocean shore at the Henlopen light-house sand-dune to the new piers of the fish house on the shore of Delaware Bay. This work was executed on the 17th and 18th of April, and comprised three and a half miles of coast line, four and a quarter miles of extreme high-water line, and about one-quarter of a square mile of area.

Mr. Hergesheimer reports the following results of his survey: The sea face of the Henlopen light-house dune, immediately in front of the light-house, and two hundred and twenty meters therefrom, is cutting away, so that for a distance of about one hundred meters it shows a caving face of sand, ten to fifteen feet high. The high-water line at the northeast point of the dune has retreated about five meters since 1882.

At two points four hundred and seventy and six hundred and seventy meters in a direct line from Cape Henlopen light-house, the sea washes at extreme high water through openings in the beach of widths of ten and seventy-five meters respectively, communicating between the sand hills with a low wet flat, which lies to the northward of the dune and extends for about a mile east and west.

The beacon light, which in 1882 stood above high-water line, is now about twenty meters outside of the same and seems to be in great danger of destruction by storm.

Since 1882 the extreme northeast point of the cape has advanced forty meters seaward while the extreme northwest point has retreated twenty meters.

At extreme high water the sea washes over the northwest face of the cape, and is gradually undermining and cutting away the sand hills between that face and the beacon light, having made inroad at a point about one hundred meters below the beacon to within fifty meters of the ocean.

Two piers, each three hundred meters in length, and one hundred and seventy meters apart, the nearest six hundred meters westward of the Government pier, have been built within the last twelve months, as has been also the Lewes life-saving station, located four hundred and twenty meters east of the railroad wharf and about twenty meters from the beach.

These facts being of much importance as involving changes in "aids to navigation" in the vicinity of Cape Henlopen, a "Notice to Mariners" (No. 51) was issued with special reference to the inroads of the sea upon the position of the beacon light, and to the intention of the United States Engineers to fill in the channel between the eastern end of the ice-breaker and the western extremity of the breakwater by laying the foundation for a continuous wall of stone.

Since the publication of this notice the Light-House Board has issued one informing navigators of changes in the characteristics of the lights of Cape Henlopen.

Under a previous heading in this section report was made of duty executed by Assistant Hergesheimer on the shores of Long Island Sound. Other service assigned to him will be referred to under the head of Section III.

Hydrographic resurvey of Lower Delaware Bay.—During the summer and autumn of 1883 the hydrographic resurvey of the lower part of Delaware Bay from Mispillion Creek light-house, on the western shore to Cape Henlopen, was carried on by the party in charge of Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Arago. His work was comprised in two hydrographic sheets, each on a scale of 1–20000, the first one including the area between the shore and the main channel; the second, that part of the lower bay between the breakwater and Brandywine Shoal.

The tide-gauge taken as a standard was a plain box-gauge, established on the Government iron pier at the Delaware Breakwater. Observations were taken at this pier every day during the season of hydrographic work, and night observations were taken also when needed for comparisons with other gauges. A temporary gauge was established at Cape May Landing to make a comparison between the tides at that point and those at the Breakwater. Other temporary gauges were put in place, but were abandoned after a few days' observations, two of them being carried away by gales. One of these was the gauge secured to Barrel signal, at which enough observa-

tions were obtained to be used for a comparison with the tides at the iron pier. For the tides at this last named point, Lieutenant Hanus has submitted a full tide-table, derived from observations made during one lunation.

Many recommendations are made by Lieutenant Hanus in regard to changes in the location of buoys in the lower bay, some of which are deserving of careful consideration. He has made notes also of changes desirable in the sailing directions as depending upon facts brought out during the progress of his survey. The intended closing of the gap between the eastern end of the ice breaker and the western end of the Breakwater will, he observes, very much improve the harbor. The current being then compressed between the eastern end of the Breakwater and Cape Henlopen Point will gradually wear away the latter, and lead to a deepening of the water in the harbor.

The following-named officers were attached to the party: Lieut. W. G. Cutler, U. S. N.; Ensigns E. F. Leiper and G. R. French, U. S. N.

Statistics reported are:

Miles run in sounding	946
Angles measured	4,717
Number of soundings	43,996

Other hydrographic duty assigned to Lieutenant Hanus during the year will be referred to under the heads of Sections III, IV, and IX.

SECTION III.

MARYLAND, VIRGINIA, AND WEST VIRGINIA, INCLUDING BAYS, SEAPORTS, AND RIVERS.

(SKETCHES Nos. 1, 4, AND 5.)

Determinations of gravity by pendulum experiments, and comparisons of standards in Europe and in the United States.—The special duty assigned to Assistant Charles S. Peirce in Europe towards the beginning of the present fiscal year was referred to in my last annual report. In June and July, 1883, he carefully compared the Coast and Geodetic Survey standard yard No. 57 with the imperial yard No. 1, and also with the iron yard No. 58 at the British Standards Office, London.

At the Kew Observatory he determined the flexure of the pier used for pendulum experiments in 1878. This could not be done at the time because the Kew Observatory is built upon the ruins of an ancient monastery, and the pier used rested upon three stories of old vaulting. It was impossible to get to the bottom of this, it being filled up with old rubbish. There was, therefore, nothing to rest a microscope upon so that it would be immovable while the pier swayed, and the attempt to determine the flexure was at the time abandoned. Subsequently Mr. Peirce invented the method of measuring the flexure by a noddy or inverted pendulum, which is set in motion by the swaying of the pier. A memoir upon this subject appears in Appendix No. 15. Also in Appendix 16 a paper on the effect of the flexure of a pendulum upon its period of oscillation.

Afterwards, in Geneva, he measured the flexure of the table upon which his pendulum support rested in the experiments of 1875, these experiments having been made just before his discovery of the importance of taking account of the flexure of pendulum supports.

Arriving in Paris, he directed further work on the designs of the new Gautier pendulums, and continued to give attention to this subject after his return to the United States in September, 1883.

Having resumed the direction of the pendulum work at the Coast and Geodetic Survey Office, he was engaged there during part of the winter in swinging the yard and meter pendulums at high and low temperatures, thus determining the ratio of the yard to the meter, and also the coefficient of expansion of the two pendulums.

At the pendulum station at the Smithsonian Institution, pendulums Nos. 2 and 3 were oscillated and the length of pendulum No. 3 was measured.

From February 1 to June 30, 1884, Subassistant F. H. Parsons was attached to Mr. Peirce's party, and observed oscillations at the office.

Comparative determinations of gravity with the Kater pendulums at Washington.—Special refer-

ence was made in my last annual report to the valuable comparative determinations of gravity obtained by Assistant Edwin Smith with the Kater pendulums at the Transit of Venus station in New Zealand, at stations in Australia and Eastern Asia, and at the pendulum station in San Francisco. These three invariable pendulums had been swung by Lieutenant-Colonel Herschel, R. E., at Kew, Greenwich, and Langham, England, and at Washington, and Hoboken near New York, in 1881–'82, and to complete the series of comparative determinations Assistant Smith was instructed to swing them at the station of Lieutenant-Colonel Herschel in the Smithsonian Institution, Washington.

The rebuilding of one of the wings of the Smithsonian Institution, which was in progress at the time of Mr. Smith's return to Washington in July, 1883, delayed the experiments, and it was not till March, 1884, that the room occupied by Lieutenant-Colonel Herschel could be placed at his disposal.

A full report and record of the observations made at this and other stations in pursuance of my instructions issued in September, 1882, has been submitted by Mr. Smith, and will appear as Appendix No. 14.

Annual determination of the magnetic declination, dip, and intensity at the station on Capitol Hill, Washington.—For the determination of the annual change in the values of the magnetic declination, dip, and intensity, observations have been made every year for seventeen successive years by Assistant Charles A. Schott at the magnetic observatory on Capitol Hill, Washington.

In 1883 the days of observation were June 18 and July 5; in 1884 June 16 and 17.

The annual change of these elements, as recognized heretofore, is sustained by the new observations. The expression for the declination was reconstructed, resulting in a slight improvement of the representation, which extends now over twenty-eight separate values between 1792 and 1884.

Longitude of Covington, Va., determined by telegraphic exchanges of signals with Washington, D. C.; also observations for latitude of Covington.—Application having been made by citizens of Virginia for the determination of the geographical position of Covington, Alleghany County, Subassistant C. H. Sinclair was instructed to organize a party for that work by the occupation of a station in Covington. Subassistant F. H. Parsons was directed to co-operate with Mr. Sinclair by exchanging longitude signals with him from the Coast and Geodetic Survey station at the Naval Observatory, Washington.

Preparations were complete at each station about the 20th of December, 1883, but owing to cloudy and stormy weather it was not till December 28 that an exchange of longitude signals was effected. On January 3 and 5 two more nights were obtained for longitude signals, completing the determination to the degree of accuracy required.

From the center of the transit pier at Covington, a meridian line was traced by Mr. Sinclair for a distance of 310½ feet, and its northern extremity was marked by a stone post. This post and the transit pier were placed under the protection of the town authorities.

For the latitude of Covington fifty observations were made on fifteen pairs of stars on four nights with meridian telescope No. 13.

Early in January field operations were closed at the two stations. The records and results of the work have been forwarded to the office.

Occupation of stations for connecting with the triangulation the corner stones and boundary monuments of the District of Columbia.—It having become desirable to determine in geographical position the original corner stones of the District of Columbia, and such of the original mile-stones as remained on the boundary lines, Subassistant C. H. Sinclair was instructed in March, 1884, to make the arrangements necessary for this work.

The data extant in the office archives in relation to the points of the original surveys had previously been carefully collated by the Assistant in charge. He found that the initial point at the south corner of the district, which was marked with much ceremony at Jones Point, near Alexandria, on the 15th of April, 1791, is shown on a topographical sheet executed in 1864. Two of the boundary stones are also plotted in position upon this sheet, and the accuracy of the original work by Ellicott is indicated by the fact that a line drawn upon the topographical sheet of 1864, starting from the initial point and (as originally laid out) making at the outset an angle of 45° with the meridian of that point passed exactly through these two boundary stones. A sec-

ond topographical sheet, executed in 1863, shows nearly all of the original measurements along the southeastern line from the Potomac to the east angle of the district. The north angular point, near the house of the late Montgomery Blair, is shown upon a topographical sheet of 1864. Of the west angular point nothing definite could be learned.

The positions thus shown on the topographical sheets were as accurate as their scales of survey, 1-10000 and 1-15000 would admit of. To bring these positions into connection with the triangulation Mr. Sinclair began his reconnaissance at Jones Point towards the end of March, and by the 19th of April had completed it, erected the necessary signals, and made the observations. The stations of this triangulation and those of the triangulation of 1880-'81 were then carefully marked, earthenware bottles, placed three feet below the surface, being used for the underground marks, and for the surface marks, granite blocks 6 inches square and 2 feet long.

Forty stations were thus marked. Field work was finished May 21. Mr. J. Howard Gray rendered acceptable service in the party. The statistics are:

Number of angles measured	76
Number of observations made	926

Other duty assigned to Mr. Sinclair is referred to elsewhere under the heading of this section and under that of Section II.

Continuation of the detailed topographical survey of the District of Columbia.—At the beginning of the fiscal year, July 1, 1883, the topographical survey of the District of Columbia which had been carried on since February, 1881, on a scale of 1-4800, had been generally completed over an area bounded on the east by a line drawn northeast from the junction of North Capitol street and Boundary avenue to the northeast boundary line of the District, thence following the District line to a point midway between the Sargent and Riggs roads; thence about southwest to the northwest corner of the grounds of the Soldiers' Home; thence following the Rock Creek Church road to Seventh street; thence up Seventh street to Piney Branch. Following the eastern slope of Piney Branch Valley to its junction with Rock Creek, the line referred to crossed in a westerly direction to a point midway between the creek and the Tenallytown road, and thence ran in a southwesterly direction to the northwest corner of West Washington (Georgetown).

In addition to the area thus outlined, the survey covered a considerable margin on each side of the New Cut road from West Washington to the distributing reservoir. Within the larger area some places, chiefly woodland, remained to be finished.

On the 1st of July Assistant Donn moved his party to the vicinity of Brightwood and began the extension of the survey out the Seventh-street road to Silver Spring, the point of crossing the District line, and over the area lying between that line and the western margin of the work completed during the preceding fiscal year.

There were no large bodies of woodland to impede progress, but, before the period of harvest, the growing grain and corn-fields and the numerous fences overgrown with briars and bushes presented obstacles of not a slight character. About the 1st of October, work in this locality having been completed, the survey of the unfinished areas already alluded to was taken up, and early in the winter was finished. The survey was then resumed in Rock Creek Valley, at the mouth of Piney Branch, and carried up the creek to the dam of Blagden's mill. The winter was favorable for the survey of the extensive woodland upon the Blagden and Shoemaker estates, but the contouring was of an intricate character. By the close of the winter or before the coming of the leaves the most difficult part of the contour work in the District was completed, the survey having been finished in Rock Creek Valley to Blagden's mill, and in Broad Branch nearly to the Military road.

When the foliage became so dense as to prevent a further continuation of the survey of those valleys, the party was transferred to the vicinity of the Potomac, above West Washington. The shore-lines of the river were surveyed as far as the distributing reservoir, and the topography was extended out the Foxhall road and along the western slope of Foundry Branch.

A map showing the area surveyed to the close of the fiscal year accompanies the report of Assistant Donn. He acknowledges the earnest and intelligent assistance rendered by Assistant Wainwright. With regard to the character of the work executed, he observes that little was left to imperfect or uncertain methods. It represents actual determinations by the plane table, or by

that and the level combined. Not only the positions of every house and outbuilding were determined, but their lines were accurately laid down. The completed record of the survey will embrace not only the topographical sheets, but the positions and descriptions of thousands of bench-marks, the great value of which will become apparent when the time arrives for laying out avenues, parks, and other works of improvement demanded by the development of the rapidly growing capital.

The statistics presented by Mr. Donn are for the details of field-work during the forty months that the survey has been in progress:

Miles of shore-line of creek surveyed	42
Miles of shore-line of river	3
Miles of shore-line of canal	3
Miles of avenue and public roads	60
Miles of park and other private roads	40
Miles of railroads (horse and steam) surveyed	3
Number of actual contour lines run	2,500
Number of level-lines (direct and connections)	200
Number of level stations for contouring	10,000
Number of plane-table stations for contouring	2,500
Number of bench-marks established	2,000
Area surveyed, in square miles	16

At every opportunity Mr. Donn continued the office work of transferring topography from the three plane-table sheets upon which the survey was originally projected to the smaller sheets substituted for them as the work advanced. The large sheets had become much worn by exposure during several field seasons, and by handling in the processes of copying and tracing.

Topographic resurvey of the shores of Cherrystone Inlet, Va.—In pursuance of instructions issued towards the end of May, 1884, Assistant E. Hergesheimer proceeded to Cherrystone, Va., on the eastern shore of Chesapeake Bay, and made a resurvey of the shores of Cherrystone Inlet from its entrance to Cherriton City, and to Westcott's, on the opposite shore.

Comparisons with Assistant Donn's survey of 1870 showed the following changes: At Westcott's Point, the outer point of the north side of the inlet has advanced southward one hundred and twenty meters; at Mill Point, on the southeast side of the inlet the northwest face of the point has retreated about twenty-five meters; the northwest face of Fisher's shore, on the southeast side of the inlet, above King's Creek, has retreated about sixty meters; Cherrystone Island at the north end has retreated five hundred and fifty meters, and since Assistant Bradford's survey in 1873, one hundred and twenty meters; the south end of the island has advanced one hundred and twenty-five meters. At the southeast entrance to the inlet below King's Creek, at the extreme point of the curve between Tazewell station and King's Creek, the shore has retreated thirty meters.

On the 10th of June, at low water, Mr. Hergesheimer measured with special care the width between low-water lines of the entrance to King's Creek and found it to be sixty-nine meters, or very nearly 75.5 yards. A knowledge of this width is important to the owners of land on the creek, as the laws of Virginia provide for certain oyster privileges where the entrance to a creek between low-water lines is not more than one hundred yards.

The marble post marking Cherry Grove station was found and Tazewell station was re-marked, but of Cherrystone station, on the island of that name, no trace could be found, the severe gale that swept over the island in August, 1878, having probably obliterated the station marks.

Other field-work executed by Assistant Hergesheimer has been referred to under the heading of Section II.

Topographic survey in the vicinity of the headwaters of Lynnhaven Bay, Va.—Additional details of topography being needed to complete the surveys in the vicinity of Norfolk, Va., Assistant Eugene Ellicott was directed to proceed to that city towards the end of May, 1884, and take up the topography of the headwaters of Lynnhaven Bay.

On reaching the field he found that most of the points of the old triangulation had been lost or destroyed; this occasioned delay in beginning the plane-table survey, and it became advisable to devote the limited time available for the work to the completion of shore-line and the location

of the new Virginia Beach Railroad. This was accomplished by the 28th of June. Statistics of the work are:

Miles of shore-line surveyed	18
Miles of roads	5
Miles of railroad	4
Area surveyed in square miles	15

Reference has been made under the heading of Section I to other field-work assigned to Assistant Ellicott.

Hydrographic surveys in the south branch of Elizabeth River, and in North Landing River and Back Bay, Va.—Upon the completion of certain hydrographic work in North Carolina, which will be referred to under the heading of Section IV, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Arago, was directed in the spring of 1884 to make a hydrographic reconnaissance of the south branch of Elizabeth River and of North River and Back Bay.

To obtain a plane of reference for the soundings in Elizabeth River (south branch), the bench-mark established by Lieutenant-Commander Thomas, U. S. N., on the sea-wall in the timber slip at the Norfolk navy-yard was used, and for comparison with it a second gauge was placed at the iron railroad bridge five miles above the navy-yard. The soundings show that the water has deepened since the former survey, and Lieutenant Hanus attributes this to the fact that the extensive dredging near Norfolk has caused stronger tidal currents above. For this work the statistics are:

Miles run in sounding	45
Number of soundings	4,268

For the hydrographic reconnaissance in Back Bay, which is an extension northward of Currituck Sound, Lieutenant Hanus anchored the Arago as close to the entrance of the bay as possible. He found that only two and half feet of water could be carried from Currituck Sound into Back Bay, but in the bay proper an average depth of from five to six feet was developed. A species of grass grows all over the bottom of this bay, and in summer, when it reaches its full height, it is said to be almost impossible for boats to move about in it. Even flat-bottomed vessels, drawing only two or two and a half feet, have to exercise care in navigating this bay on account of the thousands of obstructions in the shape of old "duck-blinds," many of which no longer show above the surface of the water. The shores of the bay are thickly settled, and the annual exports of fish and game are a great source of wealth. Statistics of the work in Back Bay are:

Miles run in sounding	131
Angles measured	11
Number of soundings	11,289

As it is well known that the tides in Back Bay are affected only by the wind, the permanent water-mark on the wharf at Knott's Landing was taken as mean low water, all other gauges and observations being referred to this mark.

In North Landing River, the head of which is in Virginia and the entrance in North Carolina, Lieutenant Hanus obtained all the soundings desired, and carried the work up the Albemarle and Chesapeake Canal, thus connecting it with the work in the south branch of Elizabeth River. In North Landing River, as in Back Bay, the only rise and fall in the water is due to the wind, and the permanent water-mark on the landing at Pungo Ferry was taken as mean low water.

All records of these several surveys have been transmitted to the office.

Lines of leveling of precision carried from Hagerstown, Md., towards Fortress Monroe, Va.—For the purpose of referring the height of the bench-mark in the transcontinental line of geodesic leveling at Hagerstown, Md., to a second point on the Atlantic coast, this bench-mark having been connected with the tidal level at Sandy Hook in 1881, Subassistant J. B. Weir was instructed to proceed to Hagerstown early in the fiscal year, and organize a party for running a line of geodesic levels towards Fortress Monroe.

Having determined the constants of his instrument, Mr. Weir began work at Hagerstown, July 24, and from that station to Weverton, Md., carried his line of levels over the Washington County Branch of the Baltimore and Ohio Railroad. The grades along this road are very heavy, in some places as much as 1 in 57, and in order not to have the line of sight running too near the ground, the sights taken were very short. It was found by experience that work done on clear and calm days during the time of the greatest heat from about 10.30 a. m. to 2.30 p. m. was not trustworthy.

From Weverton to Alexandria, Va., the line of levels followed the tow-path of the Chesapeake and Ohio Canal. No special difficulties were encountered in this reach except those due to the numerous sharp curves in the canal, which compelled many short sights to be taken. On reaching the aqueduct bridge across the Potomac, it was found that the instrument could be readily set up on any one of the eight stone piers on which the bridge rests, thus permitting short and equal sights to be taken under very favorable conditions. A bench-mark having been established on the north side of the river, and one on the south side, three independent lines were run between these benches.

From Alexandria to Ashland, Va., where the work closed for the season, the line was carried along the Alexandria and Fredericksburg Railroad to Quantico, and thence along the Richmond, Fredericksburg and Potomac Railroad to Ashland. Between Fredericksburg and Ashland there were four bridges or trestle works; great care was exercised in crossing these, the instrument being first set up on solid ground, as near one end of the bridge as possible, and the two leveling rods set up successively on a bench-mark established at a suitable distance from the instrument. The readings of the rods having been noted, they were transferred to the center of the bridge, and having been placed successively on the same point, from three to five sets of observations were made on each rod. The instrument was then transferred as soon as possible to a station established on the solid ground near the other end of the bridge, the rods remaining at the center, and from three to five sets of observations again made on each. The series over the bridges was then completed by placing the rods on a bench-mark at some distance from the instrument and again reading them. The foresights and backsights being taken in opposite directions over distances of nearly equal length, and the time elapsing between the two sights being short, it was assumed that they were made under the same atmospheric conditions, and that they were equally affected by any change of refraction caused by the line of sight passing over water.

Field-work was suspended for the season on October 31, and a bench-mark established on the Duncan Memorial Chapel at Randolph and Macon College, Ashland, Va.

The method of working throughout the season was that followed on the line of transcontinental levels, namely, to run two parallel lines simultaneously in the same direction, one by rod A, the other by rod B, the rods being placed at different distances from the instrument—geodesic level No. 1. In order to eliminate any cumulative error that might result from running constantly in one direction, alternate sections of the line were run in opposite directions.

As the work progressed the field computations were kept up, and after the close of the season the records, original and duplicate, and statements of resulting heights of bench-marks were completed and forwarded to the office. For the two lines the field computations indicated a probable error of eight-tenths of a millimeter per kilometer, or about three-hundredths of an inch in five-eighths of a mile, and in the height of the bench-mark at Ashland a probable error of a little more than half an inch (13.3^{mm}).

Mr. John Nelson served as acting aid in the party; the efficient and cheerful assistance rendered by him is acknowledged by his chief.

Later in the year Mr. Weir was assigned to duty, reference to which will be made under the heading of Section VIII.

Connection of the astronomical station at Strasburg, Va., with the triangulation; magnetic observations at Strasburg.—The geographical position of Strasburg had been determined in 1881, but as it was not then practicable to connect the station with the primary triangulation, that work was postponed. Towards the end of May, 1884, Subassistant C. H. Sinclair was directed to make a reconnaissance for the purpose of completing this connection. Starting from the line Bull Run–Mount Marshall as a base, Mr. Sinclair found that a third point, "High Knob," could be located on the Blue Ridge, commanding views of Strasburg and of the Massanutten Range, from which

also the Strasburg station could be seen. On this range a new point, "Keller," was established, and the connection made with Strasburg by means of the triangles, Bull Run–High Knob–Mount Marshall; Keller–High Knob–Mount Marshall; and High Knob–Keller–Strasburg. All of the stations needed were occupied and observations finished June 24.

For comparison with the results obtained at Strasburg for magnetic declination in 1873, at which time it had been occupied as one of the stations in the Bache Fund magnetic series, a second determination was made by Mr. Sinclair near the old station, June 25, 26, and 27, with the Bache Fund magnetometer.

Mr. Sinclair commends the untiring energy of Mr. Isaac Winston, who was attached as aid to the party. Statistics of the triangulation are:

Number of stations occupied	5
Number of angles measured	26
Number of observations made	546

Other duty executed by Mr. Sinclair is referred to under the heading of this section and under that of Section II.

Determination of the longitude of Charleston, W. Va., by exchanges of telegraphic signals with the station at Louisville, Ky. All observations for the latitude of Charleston.—A longitude station had been erected in 1881 in the grounds of the State capitol building in Charleston, W. Va., in anticipation of its immediate occupation. Unforeseen events compelled a postponement of the work. In August, 1883, advantage was taken of the presence of a longitude party at Louisville, Ky., in charge of Assistant G. W. Dean, to determine the longitude. Subassistant F. H. Parsons was directed to occupy the Charleston station.

Between the 16th and 25th of August, longitude signals were successfully exchanged on five nights, after which Mr. Parsons exchanged places with Mr. Carlisle Terry, jr., who had made the observations at Louisville. In the new position of observers successful exchanges were obtained on six nights between August 29 and September 5, completing the longitude work.

For the latitude of the station at Charleston, one hundred and eleven observations were made on twenty-one pairs of stars on six nights, Mr. Parsons observing on three nights and Mr. Terry on three. In these observations transit No. 6, which had been adapted for use as a zenith telescope, was employed.

Other determinations of longitude by Assistant Dean, Subassistant Parsons, and Mr. Terry, are referred to under the headings of Sections XIII and XIV.

Extension westward of the primary triangulation near the thirty-ninth parallel in West Virginia and Ohio.—Reference was made in my last annual report to the work of Assistant A. T. Mosman, in charge of a party which, at the beginning of July, 1883, had been engaged since the 20th of May of that year in the continuation of the primary triangulation near the thirty-ninth parallel in West Virginia and Ohio. It was found necessary to erect high tripods and scaffolds at three of the stations to be observed upon. In this duty Assistant Mosman had the aid of Subassistant Pratt from May 29 until June 30, when he was detached. All of the difficulties presented by the nature of the country, and by the necessity of hiring inexperienced hands for this service, were overcome by the skill and energy of Mr. Pratt, to whom, as Mr. Mosman states in his report, is due the successful completion of this portion of the work in a short time and at small expense.

On the 9th of July Mr. Mosman organized his party at Milton, W. Va., and by the 15th of that month was at Pigeon station, thirty miles distant, in readiness to begin observations. Heliotropers having been posted, and all lines opened, the work was pushed at all intervals of favorable weather. By the 5th of August all needed observations had been obtained. A road having in the meantime been built up the mountain at Piney station, W. Va., camp was pitched there about August 11; concrete piers for the theodolite and the meridian telescope were built, and by the 21st all was in readiness for observations. Measurements of horizontal angles, and observations for time, latitude, and azimuth, were made until September 24, many interruptions having occurred from rainy and stormy weather. While work was in progress at Piney station two tripod and scaffold signals were built, one at station Wray, in Ohio, eighty feet high, and one at station Oakland, Ky., fifty feet in height.

ERRATUM.

(At foot of page 46.)

Line 17 of this page, for "All" read "Also."

Unfavorable weather delayed the beginning of observations at the next station, Davis, in W Va., until October 8. The measurements of horizontal angles required here were completed October 19, and station Gebhardt, W. Va., was occupied between October 28 and November 10. After that date, and until December 4, when the season closed, the party was employed in visiting and marking stations, and obtaining reconnaissance angles, to get the height needed for a tripod and scaffold signal at station Gould, in Ohio. In this duty very cold and stormy weather was encountered.

Mr. W. B. Fairfield, extra observer, was attached to the party from July 15 to the end of the season. The highly efficient and satisfactory manner in which all of his duties were discharged is commended by Mr. Mosman in his report. The observations for zenith distance with the vertical circle, and those for latitude and value of micrometer, were made by him, and he assisted in the observations for time and azimuth. Mr. W. O. Jones served as recorder.

Statistics of the field-work are as follows:

Number of stations occupied	4
Number of tripod and scaffold signals erected	5
Measurements of primary horizontal directions	1,634
Measurements of tertiary horizontal directions	43
Heights determined with vertical circle	882
Differences of heights measured with micrometer	227
Number of observations for time	475
Number of observations for latitude	230
Number of observations for azimuth	144

The original records of the work were sent to the office as each station was completed. During the winter Assistant Mosman was engaged in making the computations and preparing the duplicate records for transmission to the office. In May, 1884, he was instructed to resume the triangulation, and was so occupied in the field at the close of the fiscal year.

Determination of the boundary lines between the States of Pennsylvania and West Virginia.—A full account has already been given, under the heading of Section II, of the survey and marking of the meridian and parallel boundary lines between the States of Pennsylvania and West Virginia at the request of the Joint Commissioners of those States. The meridian boundary, as determined by Subassistant Sinclair, and as marked by himself and Subassistant Van Orden, after adoption by the Joint Commissioners, was a straight line through the southwest corner of Pennsylvania and the first stone south of the Ohio, this stone having been placed in the meridian of the granite monument on the Ohio and Pennsylvania boundary. After the completion of this work, a portion of the boundary which runs eastward from the southeast corner of Pennsylvania was traced out and marked. This line follows the parallel of 39° 43′.3 nearly for a distance of about fifty-five miles to the Maryland corner. More detailed mention of these operations will be found, as just stated, under the heading of Section II.

SECTION IV.

NORTH CAROLINA, INCLUDING COAST, SOUNDS, SEA-PORTS, AND RIVERS. (SKETCHES NOS. 1, 5, AND 6.)

Triangulation, topography, and hydrography of North River, N. C.—In pursuance of instructions issued in February, 1884, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Arago, proceeded to North River, N. C., for the purpose of making a survey of that stream. Having measured a base line, signals were erected for the triangulation, and after a sufficient number of points had been determined, the topography of the shores of the river was connected with the south end of the southern cut of the Albemarle and Chesapeake Canal, and the hydrography was completed to Currituck Sound.

The tides in North Landing River being affected by the wind only, Lieutenant Hanus assumed a mean low-water level corresponding to the permanent water-mark on the coal wharf, observing that this mark agreed with the two-foot mark on the gauge which he had established on this wharf.

Ensigns E. F. Leiper and G. R. French, U. S. N., assisted in the survey. The statistics are:

Number of stations occupied in the triangulation	37
Number of stations determined	40
Number of angles measured	421
Miles of shore-line surveyed	20
Miles of creeks and roads	6
Area of topography in square miles	9
Miles run in sounding	41
Angles measured	177
Number of soundings	3,940

Other hydrographic work executed by Lieutenant Hanus is referred to under the headings of Sections II, III, and IX.

Verification of hydrography for the Atlantic Coast Pilot.—In order to obtain a careful revision of sailing directions for the Atlantic Coast Pilot by following the same and verifying the courses and depths, Lieut. J. E. Pillsbury, U. S. N., Assistant, Coast and Geodetic Survey, was directed in November, 1883, to make the verifications needed for the first subdivision of Volume IV, Atlantic Coast Pilot, south of Cape Henry.

Proceeding to Hampton Roads with the intention of taking command of the schooner Ready, Lieutenant Pillsbury availed himself of an interval before the arrival of that vessel to make a short preliminary cruise through the sounds of North Carolina. For this opportunity, which he found to be of great advantage in obtaining a personal knowledge of these sounds, he was indebted to the courtesy of the officers of the light-house tender Violet. He was thus enabled to visit Pamplico River, the Pungo, Hatteras Inlet, Bodie's Island anchorage, and Edenton, returning to Hampton Roads to join the Ready. Thence he proceeded to the outside coast, and subsequently to Washington, where he awaited the arrival of the steamer Arago.

The Arago having been fitted for winter work, Lieutenant Pillsbury resumed command of her, and left Washington December 12. Through the kindness of Marshall Parks, esq., president of the Chesapeake and Albemarle Canal Company, a pass was obtained for the Arago through the canal. While passing through, a reconnaisance of it was made to obtain data for showing its course and direction on the smaller scale charts.

All the important points in Pamplico and Albemarle Sounds were visited in the Arago. On reaching Core Sound it was found impracticable without very great labor to take the steamer over Piney Point Bar; Lieutenant Pillsbury decided, therefore, to leave the vessel and proceed by rail to Wilmington to make the examinations required in Cape Fear River. At Wilmington a steam-tug was placed at his disposal through the kindness of Mr. Henry Bacon, assistant engineer officer in charge of the improvements in the lower river. These improvements are still in progress; channels are to be dredged through three shoals between Orton's Point and Eagle Island; the changes in topography and in the soundings, resulting from works of construction, will involve the necessity of resurveys as soon as these works have progressed sufficiently.

In order to make the present chart of the river of value, Lieutenant Pillsbury forwarded to the office a copy corrected by means of data obtained from the assistant engineer.

The two charts showing the river from near Wilmington to its mouth have been brought up to date, and are now ready for issue.

Having remarked a considerable change in the Swash Channel over the Bulkhead Shoal at Hatteras Inlet, he made a survey at this point to develop the amount of change and to correct the published charts.

Similar duty of inspection performed by Lieutenant Pillsbury on the coast of South Carolina and Georgia is referred to under the heading of Section V.

SECTION V.

SOUTH CAROLINA AND GEORGIA, INCLUDING COAST, SEA-WATER CHANNELS, SOUNDS, HARBORS AND RIVERS. (SKETCHES Nos. 1 AND 6.)

Verification of hydrography for the Atlantic Coast Pilot.—To complete the verification of courses, depths, and sailing directions for subdivision number twenty of the Atlantic Coast Pilot, included in which are the coast from Winyah Bay to Savannah, and the continuous inland passages from Winyah Bay to Fernandina, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, in the spring of 1884, was instructed to make examinations similar to those referred to under the heading of Section IV, on the coasts of South Carolina and Georgia.

Beginning at Winyah Bay, inspection was made successively at Bull's Bay, Charleston Bar, Stono Inlet, North Edisto and South Edisto Rivers, Saint Helena Sound, Port Royal and Tybee entrances, Savannah River, and the inland passages from Savannah south to Fernandina. But few changes of importance were noted. These are referred to in the following extracts from Lieutenant Pillsbury's report:

"Bull's Bay, I think, has altered somewhat since the survey by Lieutenant Maffit. I could not discover on the courses generally used in entering the bay as much water by about one foot as called for, and the shoals inside have changed to such an extent as to render an entirely different course necessary in crossing the bay.

"*Charleston Bar.*—I have seen recently many statements in print as to the changes in the Pumpkin Hill channel, and that vessels have been obliged to wait for spring tide to carry fourteen and a half or fifteen feet of water. I have endeavored to ascertain the correctness of the statement relating to the change, and my conclusion is that the chart as now issued is correct. At the office of the U. S. Army Engineers in charge of the improvements I was allowed to examine their latest surveys, and one made but three months before showed a good channel of eleven and a half feet in depth. It was, however, a very little to the southward of that shown on the chart, but so little that the chart may be said to be correct. The South Channel as shown is correct also, and at the point at which the depths of over twelve feet are continuous across this bar, the channel may be followed exactly as indicated. The Swash Channel, now under improvement, has a narrow and tortuous twelve-foot channel, but for strangers it is practicable only for ten feet.

"*Stono Inlet.*—This bar has changed radically. At the time of the survey it was shallow, and was situated far to the southward of the mouth of the inlet. It has now broken through nearly in the prolongation of the inlet, and has deepened considerably, making it necessary to correct the entire chart.

Lieutenant Pillsbury calls attention to the need of a survey of the two most difficult parts of the inland passage between Charleston and Savannah, the first extending from the Stono River, near Wappoo Creek, through Church Flats and Wadmelaw Sound; and the other, Mosquito Creek, between the South Edisto and Ashepoo Rivers.

He observes, also, that additional surveys are required in the Ashley and Cooper Rivers—particularly in the former, which has assumed considerable importance commercially since the establishment of phosphate mills on its banks.

Lieutenant Pillsbury will embody the results of his examinations in a forthcoming volume of the Atlantic Coast Pilot.

Reconnaissance for the extension of the primary triangulation in Northern Georgia and Alabama towards the Gulf coast.—In May, 1884, Assistant O. H. Tittman was instructed to organize a party for reconnaissance, with a view of developing a scheme for carrying the primary triangulation in Northern Georgia and Alabama towards the coast of the Gulf of Mexico at or near Mobile, Ala.

After visiting a number of stations in Northern Georgia, Mr. Tittman found that none of the lines connecting them were available as a base for the extension of the triangulation southward. Further examinations from points to the westward of those first visited made it apparent that the line Indian–Aurora in Northern Alabama was best suited to his purpose. The former station, just west of the boundary between the two States, is on the crest of the highest ridge east of the Coosa River, the latter on the highest ridge to the west of it, the distance between the two stations being

about forty-five miles. From this line as a base it appeared practicable to carry the triangulation down the river. East of the Coosa the highest ridges are found, and they rise to relatively mountainous proportions about twelve miles south of Anniston, Calhoun County, Ala., attaining there an altitude of about two thousand five hundred feet above the sea.

A dense haze which prevailed until the middle of June, and after that date incessant rains, delayed greatly the advance of the reconnaissance.

The last point visited was Shackford, about sixty-one miles southwest of Aurora. The heights are all thickly wooded, with a growth of hickory, oak, and pine, generally not exceeding a height of seventy feet. On account of the dense foliage it will be advantageous to continue the reconnaissance after the leaves are off the trees.

Mr. Tittman was efficiently aided by Messrs. W. B. Fairfield and J. H. Turner. He closed work towards the end of June and will resume it about the beginning of winter.

SECTION VI.

PENINSULA OF FLORIDA, FROM SAINT MARY'S RIVER, ON THE EAST COAST, TO AND INCLUDING THE ANCLOTE KEYS ON THE WEST COAST, WITH THE COAST APPROACHES, REEFS, KEYS, SEAPORTS, AND RIVERS. (SKETCHES Nos. 1, 7*a*, 7*b*, AND 8.)

Completion of the survey of the east coast of Florida, between Lake Worth and New River.—At the close of the last fiscal year the shore survey of the eastern coast of Florida had been finished with the exception of that part of the coast between Lake Worth and New Inlet. In November, 1883, Assistant B. A. Colonna was directed to organize a party to fill up this gap in the general mapping of the east coast.

The officers assigned to assist him in this duty were Ensign T. G. Dewey, U. S. N., who acted as executive officer of the sloop Steadfast, and who was placed by Mr. Colonna in charge of the hydrographic work, and Messrs. T. P. Borden and E. L. Taney, Aids, who had each a plane-table for the execution of the topography.

All preliminary arrangements having been completed, the party rendezvoused at Hillsboro' Inlet about the middle of December. The hydrography of New River and Inlet was begun soon after by Ensign Dewey, aided by Mr. Taney, and upon its completion Messrs. Colonna and Dewey sounded out Hillsboro' River and Inlet and the creeks in the vicinity. The hydrography of Lake Worth was done by Messrs. Dewey and Borden, and the unfinished portion of hydrography of Jupiter Inlet by Messrs. Colonna and Dewey. At Key Biscayne Bay, the hydrography of the head of the bay was finished, and also that of the creeks flowing into it from the northward and westward. The general limits of hydrographic work were from South Jupiter Narrows to the head of Key Biscayne Bay.

That portion of the topography beginning at Fort Lauderdale, about three and a half miles north of New River Inlet, and extending north to Hillsboro' Inlet, was executed by Mr. Taney. At Hillsboro' Inlet his work joined with that of Mr. Borden, by whom the topogrophy from Hillsboro' Inlet was completed to Lake Worth.

With regard to the character of the country surveyed, Mr. Taney remarks that on the east is the ocean beach sand ridge; back of this, New River and a mangrove swamp cut up by a great many creeks, bays, &c., and west of this pine woods. A mile or two north of Fort Lauderdale the mangrove disappears and the country between the sand ridge on the east and the pine woods on the west is simply an immense marsh, covered with saw-grass and cut up by innumerable creeks. There is, however, one principal creek, and during high water small boats may pass through to Hillsboro' Inlet.

The piece of topography which Mr. Borden regarded as the most difficult of his season's work was through the saw-grass route from Haulover Head on Lake Worth to the Rapids on Lake Worth Creek. This grass, often more than breast-high, with serrated edges and a very dense growth, did not admit of rapid progress with the plane-table. Mr. Borden began work through it at noon of one day, slept in it in his boat at night, and reached the rapids next day at 3 p.m., completing the topography.

Four stations were occupied under Mr. Colonna's direction during the season for determining

the magnetic declination, dip, and intensity. His report expresses his gratification with the earnest efforts made by the members of his party to advance the work, and praises their cheerful endurance of all privations and discomforts incident to its rapid execution. Field operations were closed early in April. Upon returning to the office Assistant Colonna remained in charge of the party, directing the office work until May 15, when he was relieved and directed to prepare for duty in the Strait of Fuca, W. T. Ensign Dewey was detached May 1. The records and computations of the survey were completed by Mr. Borden.

The statistics presented of the season's work are:

Miles of shore-line surveyed	150
Miles of creeks and saw-grass	28
Area of topography in square miles	90
Miles run in sounding	205
Inlets and bars sounded out to sea	4
Number of soundings	18,128
Magnetic stations occupied	4

Observations of currents off the east coast of Florida continued.—Mention has been made under the heading of Section II of the continued prosecution of the observations of ocean currents by Lieut. J. C. Fremont, jr., U. S. N., Assistant, Coast and Geodetic Survey, commanding the schooner Drift.

In February, 1884, the Drift was prepared for similar work in the Gulf Stream, and left port under the command of Lieutenant Fremont March 4.

The stations occupied crossed the stream between Jupiter Inlet, east coast of Florida, and Memory Rock, Bahama Banks.

The experience acquired during previous seasons led to improvements in the plans of the cruise and in the instruments and methods of observation. Except in the case of the station near Memory Rock, the general characteristics of the current of the Gulf Stream were the same as those observed the year before. The direction of the current at the several stations was north, though varying a few degrees on either side. The velocities differed according to locality, those very near the shore being of less velocity than those farther out. But, contrary to expectation, the greatest velocity was not found at the supposed center of the stream, but somewhat westward of it. The greatest velocity noted was four and seven-tenths knots, in latitude 27° 05′ north and longitude 79° 44′ west. The depth here was only one hundred and ninety fathoms; the distance west from the supposed axis of the stream nearly ten miles, and from the Florida coast about twenty miles.

At Memory Rock a current was found running in a direction between east and south, with a velocity of only from one-tenth to six-tenths of a knot. Lieutenant Fremont refers to this station as a very dangerous one to occupy in the event of a strong wind coming up from the westward. The shelly bottom has not sufficient tenacity to keep the vessel from dragging towards the rocks or bank, and if sail is made the vessel will not pay off after the anchor is clear of the bottom, but will ride to the long drift of the hawser, as to a drag, and drift rapidly to leeward. He observes further that the weather in the Gulf Stream cannot be depended upon even in April, May, and June, but that in the vicinity of his work severe and sudden blows are not infrequent. The strains upon the vessel are then enormous.

In the report of his season's work Lieutenant Fremont has embodied suggestions in regard to methods of handling the cable, the advantage of having a separate reel upon which to keep it permanently, &c. These suggestions, the result of much experience in current observations, will receive due consideration.

The Drift returned to port June 27. The statistics of hydrographic work executed by the party during the fiscal year are:

Number of current stations occupied	17
Miles run in sounding	73
Angles measured	1,152
Number of soundings	2,887

Ensigns A. F. Fechteler, F. W. Kellogg, and F. R. Brainard, U. S. N., were attached to the Drift.

Triangulation of the west coast of Florida in the vicinity of Punta Rasa.—Having refitted the schooner Quick at Manatee, Fla., in the latter part of November and beginning of December, 1883, Assistant Joseph Hergesheimer proceeded in her to Punta Rasa, on San Carlos Bay, and, in accordance with instructions, began in that vicinity a triangulation to be carried southward along the coast. The stations White Sword Point and Middle Point were recovered, and from this line as a base the triangulation, supplemented by a beach measurement, was pushed southward from San Carlos Bay across to and over Oyster Bay, and thence to Wiggins Pass, between latitudes 26° 17′ and 26° 18′ north. A distance of twenty-five miles of coast line was thus covered.

Towards the close of March preparations were made for suspending field work. On the return to Manatee to lay up the schooner, Mr. Hergesheimer stopped at Anna Maria Key, Tampa Bay, and in order to test the accuracy of the apparatus used in his beach measurement, measured with it a base 2,950 meters in length which had been established there by Assistant Ogden. This test proved satisfactory.

Mr. Hergesheimer had the services of Acting Aid J. H. Turner during the season, and found him efficient and competent in all branches of the work.

The weather was not favorable to rapid progress, high winds prevailing and much haze.

Following are the statistics of the season:

Length of beach measure in meters	18,917
Number of positions determined	28
Number of angles measured	102
Number of observations	1,692

Hydrographic surveys in the vicinity of the Anclote Keys, in Lemon Bay, and near San Carlos Bay, west coast of Florida.—Towards the close of January, 1884, the steamer Bache, having on board the hydrographic party of Lieut. H. B. Mansfield, U. S. N., Assistant Coast and Geodetic Survey, arrived in the vicinity of Anclote Keys, in pursuance of instructions, for hydrographic surveys on the west coast of Florida from the Anclote Keys southward, and in Lemon Bay and near San Carlos Bay.

In co-operation with Subassistant Vinal a search was immediately begun for shore stations, and on the 10th of February soundings were commenced and continued whenever the weather permitted, the season being unusually stormy, until April 17. During this period the hydrography was completed from latitude 28° 15′ north, to the northward of North Anclote Key, as far nearly as latitude 28° 00′ north, just to the southward of Big Pass entrance into Saint Joseph's Bay.

At Anclote the mean low-water plane of reference for the soundings was obtained from the mean of high and low waters taken day and night for two weeks. Lieutenant Mansfield states that the harbor formed by the Anclote Keys is a fine anchorage at all times for vessels drawing not over seven feet of water, being easy of access and sheltered from all winds, with good holding ground. At high water, vessels drawing nine feet can enter. Once inside no harm will ensue should the vessel ground at half-tide, the bottom being soft. This harbor is a favorite one for the spongers; as many as thirty-five small schooners have been seen there at anchor at one time.

For the inshore hydrography north of Big Pass and the soundings in Anclote River the statistics are:

Miles run in sounding	701
Angles measured	4,204
Number of soundings	36,656
Specimens of bottom taken	1,600

A sufficient number of characteristic specimens of bottom were carefully preserved with the records of the work.

After coaling at Key West, the Bache proceeded in May, 1884, to Stump Pass, one of the en-

trances to Lemon Bay. Having anchored off that pass, soundings were begun in the bay May 5, and completed on the 7th. For this survey the statistics are:

Miles run in sounding	52
Angles measured	291
Number of soundings	4,844

Proceeding thence to execute the coast hydrography from the vicinity of San Carlos Bay southward, Lieutenant Mansfield arrived at Punta Rasa, and began work off Estero Key about May 12. He found signals established in position by the topographical party that was in advance of him, and was thus enabled to push the work forward at once; he was favored also by the weather, which from having been very uncertain all winter, had then become settled. On reaching the limit of the triangulation and beach measurement at Wiggins Pass, he carried the hydrography about 10 miles further down the coast, completing it to that limit May 29.

At Lemon Bay and in the vicinity of San Carlos Bay permanent bench-marks were established near each temporary tide-gauge.

Full specimens of the bottom were taken at each angle and position, and after careful selection characteristic specimens were preserved and sent to the office.

Ensigns J. M. Orchard, J. P. Parker, J. E. Craven, and Harry Phelps, U. S. N., rendered service in the work which meets with cordial acknowledgment from Lieutenant Mansfield.

For the survey south of San Carlos Bay the statistics are:

Miles run in sounding	507
Angles measured	1,003
Number of soundings	10,426

Other work of Lieutenant Mansfield's party has been referred to under the heading of Section II.

Topographic survey from the Anclote Keys southward; west coast of Florida.—In continuation of the topographic survey of the west coast of Florida Subassistant W. I. Vinal reached Anclote, Fla., January 17, 1884, and awaited there the arrival of the steamer Bache, expecting to obtain by the courtesy of her commander transportation for himself and party and other facilities for the work. In co-operation with Lieutenant Mansfield, a careful examination was made of the coast for station marks, but nearly all traces of the triangulation of 1857–1861 had disappeared. One tertiary point was identified and the positions of two occupied stations were closely approximated. With assistance from the party on the Bache, signals were erected as near as possible to the position of the original triangulation points. These and such other signals as were necessary for continuing the topographic and hydrographic surveys were located and plotted by determinations with the sextant and plane-table.

The work was carried steadily forward, covering part of the Anclote Keys, the shores of Anclote River and of Saint Joseph's Bay, till the latter part of May, when it had reached a point about two miles south of Dunedin post-office, Hillsborough County. More than usual difficulty was experienced in conducting the survey on account of extremely shoal water along the coast.

Following are the statistics of the work:

Miles of shore-line surveyed	91
Miles of creeks	12
Miles of roads	59
Miles of boundaries of salt marsh	37
Miles of boundaries of fresh marsh	34
Area surveyed in square miles	22

Topographic surveys executed elsewhere by Mr. Vinal are referred to under the heading of Section I.

SECTION VIII.

ALABAMA, MISSISSIPPI, LOUISIANA, AND ARKANSAS, INCLUDING GULF COASTS, PORTS, AND RIVERS.
(SKETCHES Nos. 1, 6, AND 9.)

Reconnaissance for the extension of the primary triangulation in Northern Georgia and Alabama towards Mobile.—This reconnaissance, begun in Northern Georgia and Alabama by Assistant S. C. McCorkle in January, 1883, and resumed by Assistant O. H. Tittman, under instructions dated in May, 1884, was fully referred to under the heading of Section V. Starting from the line Indian-Aurora,—stations in Northern Alabama at elevations of two thousand and fifteen hundred feet respectively, Mr. Tittman, at the close of his examinations in June, reported a scheme of triangulation from this line extending in a southwesterly direction about fifty miles. He will resume the work about the beginning of winter, the absence of dense foliage being then more favorable to rapid progress.

Mention is also made, under the heading of Section I, of other duty assigned to Assistant Tittman.

Line of levels of precision carried from the Gulf coast near Mobile toward a point on the transcontinental line of geodesic leveling.—For the purpose of connecting the tidal level of the Gulf of Mexico with that of the North Atlantic by carrying a line of geodesic levels from a station near Mobile to a point on the transcontinental line of precise leveling, already referred by that line to the tidal bench-mark at Sandy Hook, Subassistant J. B. Weir was directed early in February, 1884, to proceed to Mobile and organize a geodesic leveling party.

Having established a permanent bench-mark on the custom-house in Mobile as the initial point of the line, Mr. Weir carried the work forward along the Mobile and Ohio Railroad to Citronelle, Ala., a distance of thirty-two miles. At this point, owing to the want of transportation at times suitable for the work, a bench-mark was established and the party transferred to Meridian, Miss., at which point the line of levels was resumed, and continued along the same line of railroad to Okalona, Miss., which is two hundred and sixty-one miles from Mobile. The gap of one hundred and two miles between Citronelle and Meridian will be filled hereafter. Field operations were closed at Okalona May 5.

The original records and duplicates, with maps showing the route followed, and a table of resulting heights of the bench-marks from the field computations, were transmitted to the office soon after the close of the fiscal year.

Throughout the season the method of working was that pursued on the transcontinental line of geodesic leveling, namely, to run two parallel lines simultaneously and in the same direction, one by rod E and the other by rod F, the rods being placed at different distances from the instrument, and any cumulative error that might result from running constantly in one direction being guarded against by running alternate sections of from ten to twelve miles in opposite directions.

By the field computations a probable error is shown for the two parallel lines of seven-tenths of a millimeter for a kilometer, or about three-hundredths of an inch in five-eighths of a statute mile. The instrument used was geodesic level No. 1.

Mr. John Nelson served as acting aid in the party with credit to himself and satisfaction to his chief.

Similar duty executed by Mr. Weir is referred to under the heading of Section III.

Continuation of the survey of the Gulf coast of Louisiana westward of the delta of the Mississippi.—Instructions issued to Assistant Charles Hosmer, in November, 1883, directed him to organize a party for the completion of the survey of the coast of Louisiana immediately to the west of the Mississippi River. Assistant Hosmer, at the time these instructions reached him, was engaged in work on Long Island Sound, reference to which was made under the heading of Section II, in this report.

At as early a date as practicable he proceeded to New Orleans, and took charge of the steamer Barataria, the necessary repairs to which were not completed till early in January, 1884. The survey was begun January 17, and the most important part of it finished by the 1st of April. Its locality being chiefly in the network of bays, passes, and bayous between the Lower Mississippi

and Barataria Bay, progress was much interfered with by the high stage of water in the river, and the consequent inundation of the country under survey.

Special difficulty was met with in what is known as "The Jump," an outlet of the river into Red Pass. This outlet, wide and deep at first, soon divides into a number of small streams, all of which maintain a considerable depth to the marsh line which represents the Gulf coast, and then shoal up so rapidly that it was found impossible to cross the bars in even the smallest boats. This made it necessary to postpone the execution of the inshore hydrography of the Gulf. The main passage way to the Gulf was sounded out, but it was not deemed advisable to sound the smaller streams in consequence of the continuous changes. Work in The Jump had just been completed when the great rise in the river took place, and soon after it became necessary to find a safe mooring place for the Barataria. Fortunately this was found at the custom-house wharf at the quarantine station. Field operations were closed, and the steamer taken to New Orleans, April 3.

Mr. Carlisle Terry, jr., was attached to the party as Aid, and rendered acceptable service till his detachment, March 19, for other duty.

Ensign Alfred Jeffries, U. S. N., served as executive officer and aided in the hydrographic work. The vessel was transferred to his charge to be laid up on the 10th of April.

The statistics reported are as follows:

Miles of shore-line surveyed	160
Miles of creeks	90
Area surveyed in square miles	157
Miles run in sounding	29
Number of soundings	4,153

One topographic sheet, scale 1–30000, and one hydrographic sheet, on the same scale, have been finished and forwarded to the office.

Continuation of the survey of the Gulf coast of Louisiana from Calcasieu Pass eastward.—In December, 1883, in pursuance of instructions issued towards the close of November in that year, Assistant F. W. Perkins proceeded to the vicinity of Calcasieu Pass, La., and by the 14th of January, 1884, had begun the triangulation and topography of the coast from the line Mangrove–Mud Lake, just to the west of the pass. From this line the survey was carried eastward along the Gulf coast for a distance of about forty miles to a point within about three miles of Joseph's Harbor Bayou.

Owing to the nature of the shores, which are low and subject to overflow, the impassable swamps separating the coast from the hard ridges in the back country, and the shallow bars at the entrances to the few inlets along the coast, camps are in a measure unsafe, and vessels of ordinary build are not available.

Under these circumstances, Mr. Perkins deemed it advisable to push the triangulation ahead as rapidly as the small appropriation allotted for the work would permit, and to confine the topography to those sections which could not be reached from a vessel lying in the large inlets, or from camps located on the hard ridges in the back country. By this plan the topographic survey of the more difficult and inaccessible places was completed.

For transporting camp equipage, signal lumber, and stores along the coast a small schooner of light draught was chartered, and by taking advantage of calm weather for landing on the beach no serious accident occurred, though the force of but three men was hardly enough to guard the camp against the not infrequent inroads of the sea, which threatened to sweep it away, and to take care also of the schooner outside till the water should rise sufficiently on the bar of some neighboring inlet to admit of making a harbor.

With regard to passes or inlets having shifting sand-bars off their mouths, like Calcasieu Pass, Mr. Perkins observes that the changes in depth and direction of channel are so rapid and great that no hydrographic survey or sailing directions are a safe guide to an entrance. On the Gulf coast, where the sea is so tranquil that on most days a pilot can go out in a small boat and locate the deepest part of the bar, it is not uncommon to find a system of range-beacons maintained on shore by means of which vessels enter. But as this is nearly always a private enterprise and supported by rather irregular contributions, Mr. Perkins suggests that at such entrances a system

of light movable tripods, with the necessary day and night signals, might be maintained by the Light-House Board. The cost would be slight compared with the great advantage to commerce.

Mr. W. C. Hodgkins was attached to the party as Subassistant, and Mr. George F. Bird as Aid. To the untiring energy and industry of these officers Assistant Perkins attributes much of the good progress made in the work. The statistics are:

Number of stations occupied in triangulation	12
Number of points determined	40
Number of observations made	2,920
Miles of shore-line surveyed	50
Miles of creeks and ponds	9

Field operations were closed on the 6th of May. Duty performed by Assistant Perkins during the earlier portion of the fiscal year is referred to under the heading of Section XIV.

SECTION IX.

TEXAS AND INDIAN TERRITORY, INCLUDING GULF COAST, BAYS, AND RIVERS. (SKETCHES Nos. 1 AND 9.)

Hydrographic survey of the coasts of Texas and Louisiana between Galveston entrance and Calcasieu Pass continued.—In continuation of the hydrographic survey of the coasts of Texas and Louisiana between Galveston entrance and Calcasieu Pass, Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, was instructed in the winter of 1883–'84 to take command of the steamer Gedney, and, after completing her preparation for service, to proceed with the vessel and party organized on board of her to Galveston.

The soundings were begun early in 1884, at a point off the coast about thirty miles to the westward of Sabine Pass, and carried on to a position about thirteen miles to the eastward of that pass. Lines of soundings normal to the shore were run to an average distance of forty-five miles from it. This survey was executed on a scale of 1–80000. A special survey of Sabine Pass was made on a scale of 1–20000. To obtain a plane of reference for the soundings, tidal observations were made at Galveston from March 1 to June 16, inclusive, and at Sabine Pass from June 6 to June 10, inclusive.

In April Lieutenant Heald was obliged to come north on sick leave, and the command of vessel and charge of the work was temporarily assigned to Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey. By this officer the following statistics of the season, which closed June 16, are reported:

Miles run in sounding	1,521
Angles measured	1,616
Number of soundings	45,075

Reference is made to other hydrographic duty performed by Leiutenant Hanus under the headings of Sections I, II, III, and IV.

Reconnaissance for connecting the triangulation in the vicinity of Point Isabel and the mouth of the Rio Grande with Brownsville, Tex.—The work assigned to Assistant R. E. Halter for the winter of 1883–'84 was a reconnaissance to connect the triangulation in the vicinity of Point Isabel and the mouth of the Rio Grande with Brownsville, Tex., and the continuation of the reconnaissance towards Barranco.

Mr. Halter arrived at Point Isabel, Brazos Santiago, about the middle of November, and as soon as the weather permitted began his reconnaissance. Much difficulty was experienced in recovering the points of the old triangulation, some of them having no underground marks, and the surface marks having either entirely disappeared or nearly rotted away. Having recovered stations Frontier (near the light-house), Massena, and Cameron, the reconnaissance was started from the line Frontier–Cameron, and by the close of the season in February, 1884, it had been carried to Brownsville.

Mr. Halter remarks that for about twelve or fourteen miles from the coast the locality is very much cut up with lagoons and boggy flats, and that drinking water is very bad and scarce through-

out the back country. About six or eight miles from Brownsville there is a thickly-wooded belt, to get over which tripod and scaffold signals of about forty-five feet in height must be built. A sketch showing the scheme of triangulation developed by the reconnaissance has been submitted by Mr. Halter with his report.

SECTION X.

CALIFORNIA, INCLUDING THE COAST, BAYS, HARBORS, AND RIVERS. (SKETCHES Nos. 2, 10, 11, AND 12.)

Survey of the coast of California between San Diego and Newport.—At the beginning of the fiscal year Assistant A. F. Rodgers was on duty connected with the primary triangulation of the north coast of California. In August, 1883, he was instructed to proceed to Washington for special duty, and on his return to California made arrangements for closing operations on the north coast in accordance with directions to that effect. Having visited the primary stations Bear Ridge and Mud River in order to secure reference marks for future use, and stored the instruments of the north coast survey in the suboffice at San Francisco, Mr. Rodgers made preparations for work in the new field to which he was assigned—the filling up of the gap in secondary triangulation and topography on the Pacific coast between San Diego and Newport, Cal.

This work, it had been arranged, should be begun in the vicinity of San Juan Capistrano, Los Angeles County, but before taking it up Mr. Rodgers was instructed to determine the geographical position of the magnetic observatory at Los Angeles, to the north of Newport. For this purpose the stations occupied were West Beach, Dominguez, and Los Cerritos, these being the most available ones within a circle of twenty miles from the observatory. Signals were erected upon the observatory and upon the tower of the State Normal School, and pointings made upon these and upon all prominent spires, towers, &c., in the city of Los Angeles and vicinity. Mr. Rodgers then returned to San Francisco, made the computations of this field-work, and forwarded a summary of the results to the office.

On the 5th of February, the organization of his party for the southern work having been completed, he sent forward the men and animals to San Pedro by steamer; but the winter, which up to that date had been very light, started in with a succession of rain storms which for several weeks completely blocked travel by the county roads and made rail transportation for the party necessary to Santa Ana; from thence to San Juan even the twenty-five miles remaining were traversed with some difficulty. Mr. Rodgers' own movements were delayed up to the 8th of March by a continuance of rain storms which entirely stopped travel from Los Angeles, where he had arrived on the 3d instant. Railroad bridges were washed away and stage roads rendered impassable by swollen streams.

On the 11th of March he reached San Juan Capistrano and immediately began work by measuring a base in San Juan Valley and occupying stations in the triangulation. Two topographical sheets were projected, each on a scale of 1-10000, and extending from a point five miles west of San Juan Capistrano anchorage to Point San Mateo, nine miles to the southward. The shore-line on these sheets was delineated and the relative position of objects on shore determined so as to furnish the means for a hydrographic examination of the offing and approaches to San Juan Capistrano. Field operations were suspended in June.

Following are the statistics of the survey:

Number of stations occupied in the triangulation	28
Number of positions determined	48
Number of directions measured	1,653
Number of horizontal angles measured	3,467
Length of shore-line surveyed, in miles	16
Length of shore-line of creeks, in miles	4

Assistant Rodgers is under instructions to resume this survey at as early a period as practicable in the present fiscal year.

Continuation of the series of observations at the magnetic self-registering record station at Los Angeles, Cal.—The scheme of work planned and inaugurated in the summer of 1882 at the magnetic

observatory at Los Angeles, Cal., and placed in charge of Mr. Marcus Baker, Acting Assistant, was continued under his direction during the past fiscal year. This work is twofold in character, and consists of monthly determinations on three consecutive days of the absolute declination, dip, and horizontal force, and a continuous registry by photography (with the Adie magnetographs) of the changes of declination and vertical and horizontal force.

The absolute measures were made throughout the year without interruption, the results were deduced, the records duplicated, and full special abstracts were prepared and transmitted to the office. In connection with these absolute measures, a redetermination was made of the astronomical azimuth to obtain a true meridian line of reference for the magnetic declination, and special observations for constants hitherto undetermined were made. Notable among these was the determination of the induction coefficient of the intensity magnet, by the aid of a simple apparatus devised at the observatory. All of the results of preceding years were revised, so that all the declinations are now referred to the same azimuth, while the results for intensity depend on the same set of constants throughout.

The record of variations of the earth's magnetic force was made as nearly continuous as possible by the processes of photography. Great and constant care was taken to produce traces of the highest standard. These efforts were not so successful as during the year before, owing to causes beyond the control of the director. One of these was a settling of the foundations of the piers, resulting in a weakening of the luminous dots and in a slow impairment of the adjustments. This was due to a softening of the adobe soil, produced by a phenomenal rainfall, entirely without precedent in Los Angeles and vicinity, which visited that town in February, 1884. Other causes were the impossibility of obtaining suitably distilled water for observatory use at various times during the last four months of the fiscal year, and the necessity of training new assistants in the photographic work.

The total loss of record from all causes during the year was, however, very small, amounting to but seven-tenths of one per cent.

A thermograph record was kept uninterruptedly throughout the year within the observatory, the temperature curve for each day being shown upon a separate sheet.

Equal altitudes of the sun were observed each month with sextant and artificial horizon for the determination of the local time.

Mr. Lucius Baker aided in the observatory work till the end of February, 1884, when he resigned, and temporary assistance was obtained till March, when Mr. P. A. Welker, Aid, was assigned to duty, remaining till the close of the fiscal year.

Mr. Carlisle Terry, jr., Aid, was ordered to report at the observatory for duty in April, and familiarized himself with the instruments and methods, with the understanding that he should take charge of the work when Mr. Baker's request to be relieved could be granted.

A statistical summary of the various observations is as follows:

Number of observations for time	233
Number of observations for azimuth	112
Number of observations for temperature	4, 392
Number of observations for magnetic constants	1, 599
Number of observations for absolute declination	939
Number of observations for absolute dip	3, 577
Number of observations for absolute intensity	1, 510
Number of uniform observations	8, 711
Number of bifilar observations	8, 739
Number of vertical force observations	8, 714

Statements in detail of the results of the work to the end of the fiscal year have been transmitted by Mr. Baker with his annual report; also a number of papers relating to its methods and processes.

Continuation of the primary triangulation of the coast of California north of Point Concepcion.—By instructions issued in August, 1883, Assistant James S. Lawson was directed to take the field in continuation of the primary triangulation north of Point Concepcion at such time as he would

find most favorable for obtaining the most satisfactory results. Keeping watch on the condition of the atmosphere, he made arrangements early in October for the occupation of San Luis station, in San Luis Obispo County, Cal., a point about eighteen miles from the coast and having an elevation of three thousand feet. The opening of a trail up the mountain, pitching camp, building of a pier for the instrument, and other preliminary operations having been completed, observations were begun November 9 and closed December 7.

The horizontal directions of six primary and two tertiary stations were determined, the latter for the purpose of connecting the tertiary triangulation at Esteros Bay with the main series. Observations were also obtained on Piedras Blancas light-house. To do this, a ridge about a mile distant from San Luis station had to be cleared of every vestige of shrubbery near the line of sight, and a ledge of rocks removed by giant powder, so nearly tangent to this ridge did the line of vision to the light-house tower pass. Pointings were also taken on all prominent hills and objects within the range of view from the station. The heights of five primary stations were determined by observations of double zenith distances.

The next station occupied was San José, a peak in San Luis Obispo County, distant about thirty-one miles from the coast, and having an elevation of thirty-seven hundred feet. Here, as at San Luis, camp was pitched on the south face of the mountain to obtain a shelter from the strong north and east winds coming from the Sierras across the great valley of California. At San José, between January 1 and January 19, observations were made on six primary stations, and pointings taken on all prominent hills and objects, including thirty-three peaks in the Sierras. Measures of double zenith distances were made on all main stations and prominent peaks.

The occupation of Saddle Peak, a mountain of forty-seven hundred feet elevation, within about five miles of the coast, followed next. This peak and Castle Mountain, a prominent elevation of the coast range and one of the points of the main series were not intervisible, but the peak was occupied because it had been observed upon in connection with the tertiary triangulation, though it was not included in the primary scheme. Seven stations were observed from Saddle Peak.

It had been intended by Assistant Lawson to occupy Rocky Butte, a primary station of thirty-four hundred feet elevation near the coast, but while the wagons were *en route* a violent storm of rain began, which for long duration and amount proved to be unprecedented in that region. Bridges were carried away and roads rendered impassable by deep mud and overflows of water from five to ten feet in depth. Having waited until the middle of February, and seeing no prospect of moving forward, Mr. Lawson disbanded his party and returned to San Francisco to complete the records and results of the season. In his report he expresses his high appreciation of the value of the services of Mr. P. A. Welker, who was attached to his party as Aid. The statistics are:

Number of measurements of horizontal angles	2,189
Number of measurements of vertical angles	810
Number of secondary readings	71

Assistant Lawson received instructions to resume field-work as early as practicable after the beginning of the next fiscal year.

Survey of the coast of California between Moro Bay and San Simeon Bay.—Having in accordance with instructions proceeded to Santa Barbara, Cal., to receive and store certain property of the Survey, Assistant Stehman Forney, on completing that duty, was assigned to the charge of the tertiary triangulation and topography of the coast between Moro and San Simeon Bays.

Having established his party near Cayucos, convenient to his field of work, Mr. Forney took up the triangulation from the line Beach–Chaparral to the southward of Moro Bay and carried it fifteen miles up the coast, to the line Villa–Stone, near Estero Point. The shore-line in the vicinity of Moro Bay was delineated on two topographical sheets, also the contour lines and all fences, houses, &c., including the towns of Cayucos and Moro, within a belt of one and a half miles from the shore. There is much topographical detail immediately on the coast from Moro Bay to Cambria, the contouring being intricate, and the land being cut up into dairy farms, varying from one hundred to one thousand acres. These farms are all divided by fences with roads leading to the dwelling-houses.

Field operations were closed February 29. Between that date and June 2, when the work in

the field was resumed, Assistant Forney was engaged in completing his records and computations and making tracings of his unfinished topographical sheet.

The statistics of the season are:

Number of stations occupied in triangulation	10
Number of angles measured	213
Number of observations made	7,218
Miles of shore-line surveyed	16
Miles of rivers and creeks	6
Miles of roads, fences, &c	66
Area of topography in square miles	9

The highest elevation over which contour lines were carried was eight hundred and twenty-seven feet.

Hydrographic survey in the vicinity of Point Buchon, Cal., and examination of bar at entrance to San Francisco Bay.—In continuation of the inshore hydrography of the coast of California from San Luis Obispo Bay northward, Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, left San Francisco, January 30, 1884, with his party on board the steamer McArthur, and on reaching Port Harford, San Luis Bay, prepared to execute the hydrography in that locality.

A plane of reference for the soundings was obtained by deducing the mean of lower low waters from observations made between February 13 and May 10 on a tide-staff established at the wharf at Moro Bay, San Luis Obispo County. Soundings were begun February 21 and completed May 10 to beyond Cayucos, which is the extreme northern part of Estero Bay.

Lieutenant Taussig's report gives full details in regard to the hydrographic characteristics of the localities sounded, and the notes he has made will be of much value in the preparation of the new edition of the Pacific Coast Pilot. Some extracts from his report are here given:

"Port Harford, as a summer anchorage, is very good. The northwest wind does not come home, as a rule, and there is generally a calm and perfectly smooth sea inside the reef, while outside there may be a strong northwest wind and heavy sea. In the winter months there is generally a swell setting in, which at times breaks off the end of the wharf in four-fathom water. But the holding-ground is good, and the McArthur lay out at her anchors six southeasters in February and March. To the northwest of the reef, close under the bluffs and the inner inlet, the sea is smoother and the wind harmless as a rule, but there is little room for working ship in case of accident or of an emergency. A sailing vessel could not get out of the bight in the face of a strong southeaster. At times, but rarely, a strong norther blows, which rushes down the hills with the suddenness and nearly the velocity of the 'willy-waughs' of the Straits of Magellan, and would be apt to cause a vessel to snap her chain." There is frequently a strong undertow at the wharf. A red nun-buoy No. 2 has been placed in ten fathoms of water off the fourteen-foot rock which lies about a mile to northward and eastward of the reef.

"There is generally a heavy sea off Point Buchon, and the reef extends half a mile to seaward. There is deep water near the point; but there are so many rocks about, that vessels should give the point a good offing. Point Buchon is the point having the longest reef extending from it—the point with the flat-topped bluff, not the bluff which has a hump on it.

"At Point Buchon the land turns sharply to NNE. for two miles, forming the northwestern face of Mount Buchon, the bluffs being jagged and rocky. Thick kelp is found for half a mile off shore along the whole two miles. The land then turns and curves to the north and west, the high land recedes, and the shore-line thence for about seven miles is a sand beach, broken by Moro Rock and the entrance to Moro Bay.

"Moro Bay is a lagoon emptying into Estero Bay. The entrance is to the northwest of Moro Rock and Pillar Rock; the latter is the rock just clear of Moro Rock to the west. Light-draught vessels enter with the flood tide. The channel is narrow, and changes more or less each tide. It generally breaks at the entrance with the ebb tide running. The tides run through the entrance with great velocity. Vessels drawing eleven feet have gone in and come out. There is a strong probability of touching, even with a pilot on board, and vessels entering may have to wait some time for a favorable tide. The need of a good harbor is great in this section of the country, and

it was a disappointment to me that I could not use it as an anchorage for the McArthur. Above the wharf the greater part of the bay is more or less bare at low water. No vessel should enter without a pilot.

"Cayucos is a passable summer anchorage, but a dangerous one in winter. Vessels should leave as soon as a southeaster begins, and whenever a southwest swell rolls in.

"The rapid development of San Luis Obispo County, the growing commerce of the city of San Luis Obispo, and the lack of any harbor of refuge from winter storms between Monterey and Wilmington, will before many years demand the construction of a sufficient breakwater at Port Harford to enable vessels to remain there at any time of the year."

Lieutenant Taussig's hydrographic work off the coast of San Luis Obispo County is comprised in six hydrographic sheets on a scale of 1–10000.

Upon completing this work early in the month of May, 1884, Lieutenant Taussig received instructions to make an examination of the bar at the entrance of San Francisco Bay. He completed part of this work in June, expecting to resume it in the following month. At the close of the fiscal year the McArthur was near San Simeon, a hydrographic survey in that vicinity under Lieutenant Taussig's direction being in progress.

His hydrographic work in the early part of the fiscal year off the coast of Mendocino County will be referred to later under the heading of this section. For that just reported the statistics are:

Miles run in sounding	912
Angles measured	4,556
Number of soundings	27,620
Specimens of bottom preserved	37

To the officers attached to the party Lieutenant Taussig expresses his obligations for efficient service. Those who served in the work of 1884 were Lieut. F. H. Lefavor, U. S. N., and Ensigns W. L. Burdick and P. B. Bibb, U. S. N.

Connection of the main triangulation north of Point Concepcion with the transcontinental triangulation near the thirty-ninth parallel.—A condensed report has been submitted by Assistant George Davidson of the main triangulation and astronomical work in California, under his direction, and of other work of himself and party.

Mr. Davidson delayed putting his party in the field until the fogs of summer had gone and the prospect of grass for the draft animals good. He placed Assistant E. F. Dickins in charge of the party, with Mr. R. A. Marr as Aid.

At first the season was favorable, but later on the rains were very heavy and retarded operations. Nevertheless, as Mr. Davidson remarks, the winter is the best time in that climate for getting a clear and steady atmosphere. The heliotropes always show as minute steady points of light like stars, whereas in summer they are large, ill defined, and very unsteady objects.

The plan of work embraced the occupation of several main triangulation stations on the seaboard, in the regular scheme of triangles and observations upon Red Hill and Rocky Mound, stations to the eastward of San Francisco Bay, to bring to a close the connection of the present system with the Pulgas base, measured by Assistant Cutts.

A doubt having arisen whether the line Sierra Morena–Loma Prieta (or Mount Bache) was intervisible, a reconnaissance was undertaken by Assistant J. S. Lawson, in July and August, under Mr. Davidson's direction, to settle this and similar questions as to stations in the main scheme southward to San Luis Obispo. The intervisibility of the two stations just named was established and the line has since been observed. The stations Saddle Peak and San José were found to be intervisible over an intervening ridge by a very few feet. A high mountain ten or fifteen miles southeast of Santa Ana was found to be unavailable, and the old station of Santa Ana, instead of Mariposa Peak, was subsequently taken by Assistant Dickins in thick weather. The old station, Salinas Mountain, not before observed upon however, was found to be Mount Toro, and this latter name is used.

As the work of occupation of the stations was undertaken in winter, a small hut was built over each station, instead of using an observing tent as a protection against southeast gales.

During December and January Mr. Dickins occupied Sierra Morena, a mountain about twenty miles north of San Francisco, and observed upon the mountains, Tamalpais, Diablo, Mocho; and Loma Prieta (or Mount Bache). Incidentally also upon Mount Hamilton (Lick Observatory) and upon the secondary stations Rocky Mound and Red Hill; also upon the Southeast Farallon light and San José court-house.

The observations were made with the twenty-inch theodolite No. 115, mounted on a brick pier with the Davidson position circle. The series embraced two direct and two reversed observations in each of the twenty-three positions of the instrument.

The ocular micrometer was used, after the micrometers were read, to correct the telescope pointings. In this work five hundred and eighty-two observations were made and twenty-eight hundred and sixty-seven ocular micrometer readings.

The field reductions were kept up to date, and subsequently the diminished measures were computed and transmitted to the office with the volumes of records.

Mr. R. A. Marr, Aid in the party, made the measurements of the vertical angles with the twelve-inch vertical circle No. 111. Observations were made upon the same stations that were observed for horizontal directions, through thirteen days and between midday and 1 p. m. As the work progressed, the reductions and tabulations were made, and from the suboffice these reductions and the records were afterwards transmitted to Washington. In this work the number of observations was four hundred and eighty. Red Hill, up which a line of levels had been carried by Assistant Cutts, will be occupied for measurements of reciprocal zenith distances.

Magnetic observations for declination and horizontal force were made through three and six days by Mr. Marr. He made also the necessary time observations with the sextant and artificial horizon.

The transfer of the party from Sierra Morena to Loma Prieta (or Mount Bache) was made in very bad weather, and had to be done by a circuitous route. A trail favorable for packing had to be cut out for several miles. During this work by Mr. Marr, Assistant Dickins visited Toro Mountain and Santa Ana and posted heliotropers. The snow was deep at these peaks as well as at Mount Bache.

At this station, a few miles north of Santa Cruz, and thirty-eight hundred feet above the sea, Mr. Marr built the necessary stone and cement piers. The twenty-inch theodolite No. 115 was mounted on one of the piers, which had secured to it a Davidson position circle.

Assistant Dickins observed upon the five main stations, Mocho, Santa Ana, Toro, Diablo, and Sierra Morena; incidentally upon Mount Hamilton, the San José court-house, Santa Cruz light house, and Gilroy church.

The observations were made in the usual manner with ocular micrometer readings, two readings direct and two reversed being taken in each of the twenty-three positions of the instrument. In this work four hundred and ninety-six observations were made and fourteen hundred and ninety-two ocular micrometer readings.

At this station, although the observations of horizontal directions were not completely finished, owing to want of funds, yet they were so nearly finished, and the results were obtained under such favorable circumstances of weather, that they may be safely taken as final. The records and reductions were completed and transmitted to the office.

Observations of vertical angles were made by Mr. Marr with vertical circle No. 111, upon the same stations as those observed by Assistant Dickins. The number of observations was three hundred and thirty-six.

Mr. Marr determined the magnetic declination and horizontal force on three and six days, and made the necessary time observations.

At the end of March, 1884, field operations were closed, and the party was employed in office duty.

During the year Assistant Dickins was directed to make observations upon Lime Point steam fog-horn from two or three tertiary triangulation stations to determine its position. He was detached from Mr. Davidson's party May 23, 1884.

Special magnetic observations.—During a short trip to Mexico, Assistant Davidson was able to observe the magnetic declination at El Paso, in Texas, and at the National Observatory at Tacu-

bayo, on the edge of the city of Mexico. He had the voluntary assistance of Mr. Glover Kellogg, of San Francisco.

Observations of the solar eclipse of October 30, 1883.—On the 30th of October Mr. Davidosn observed the first contact of the solar eclipse of that date, at the Davidson Observatory in San Francisco, and arranged telescopes for all officers who wished to observe it. He used the full aperture of his six and four-tenths inch equatorial, with an Airy double-image micrometer, carrying a power of two hundred and forty diameters. For obtaining the error of the chronometer, transits were observed by Mr. C. B. Hill before and after the eclipse, and comparisons of chronometers by coincidences were made after it.

Mr. Davidson remarks that the border of the sun was unsteady, and the unsteadiness increased till the time of greatest obscuration, which took place three minutes before the sun set below the ocean horizon. At that time, the boiling of the borders of the sun and moon was excessive, and the refraction was so great that the images of the two bodies, as far as visible, were remarkably flattened, and the cusps presented a very singular and abnormal appearance.

The station of observation is 0″.37 south and 0″.21 east of the triangulation station Lafayette Park. The following tabulated statement gives the names of the observers, times of observation, &c.:

Observer.	Telescope.		Local mean time of I contact.	Remarks.
	Aperture.	Magnifying power.		
	Inches.		*h. m. s.*	
Davidson	6.4	240	3 46 14.5	May be 0s.5 or 1s.0 late.
Dickins	3.0	105	27.1	Hassler equatorial.
Marr	3.0	105	28.6	Reconnoitering telescope.
Morse	2.5	50	01.5	Do.
Hill	2.2	40	17.1	Do.

Mr. Morse had the poorest telescope, and his noting of the time is probably in error, as Mr. Davidson remarks, from taking up the wrong tens of seconds.

Suboffice-work.—The work in connection with the suboffice at San Francisco was duly attended to, and all inquiries for information were answered as far as the resources of the archives would permit. During the season, with my approval, Assistant Davidson furnished to the Geographical Society of the Pacific a paper upon the alleged shoaling of the bar of San Francisco Bay. In the work of the office acknowledgment is made of the intelligent and willing assistance rendered by Mr. C. B. Hill.

Coast Pilot of California, Oregon, and Washington Territory.—To the preparation for publication of the fourth edition of this work Mr. Davidson gave all the time possible. On account of the mass of details on the southern portion, much of it had to be rewritten. The portion relating to that part of the coast from San Diego to San Francisco was completed.

To get special views of headlands, and to make notes of sailing directions, Mr. Ferdinand Westdahl was directed to make two trips down the coast. Mr. Davidson visited personally the Farallones for views, and Mr. Westdahl the Cordell Bank, but the weather was foggy on both occasions.

Mr. Davidson was summoned to Washington in June, 1884, for special conference with me relating to the interests of the work as affected by measures pending in Congress. On his return trip in July, he attended to special duty in Philadelphia, and while crossing the continent studied the comparative advantages and disadvantages of the 35th parallel relatively to the 32d for transcontinental geödetic work.

During the year the observatory at Lafayette Park was used by the members of Mr. Davidson's party for practice with the different instruments, and at the request of Maj. W. A. Jones, U. S. Engineers, stationed at the Presidio of San Francisco, arrangements were made for a joint determination of the difference of longitude between the Lafayette Park station and stations at Needles (Mohave) and Fort Yuma, Ariz. At Lafayette Park, in Mr. Davidson's absence at Washington, the observations were made by Mr. Marr, assisted by Mr. Hill. Transits for time were observed upon nine nights between May 26 and June 27. Owing to exceedingly inclement weather, and an

accident to the transit instrument at the Needles, exchanges were obtained upon two nights only with that station, and on one night with Yuma.

Other operations directed by Assistant Davidson, or carried on by his aid and advice, are referred to in the paragraphs immediately following.

Tidal observations with self-registering tide-gauge continued at Saucelito near San Francisco Bay entrance.—The self-registering tide-gauge record at Saucelito, near San Francisco Bay entrance was kept up, almost without interruption by Mr. E. Gray, under Assistant Davidson's general supervision. The usual tabulations were made at the end of each month, and were forwarded to Washington before the transmission of the records.

The earthquake waves from the volcanic eruption at Krakatoa off the coast of Java, August 26, 1883, were recorded upon the Saucelito tide-gauge a few hours after that event, and the fact was published before any notice of the earthquake had been made public. The record shows that the earthquake waves may have come through several tracks to this station.

Determinations of the force of gravity in San Francisco, in connection with similar observations in Alaska.—Reference was made in my last annual report to the dispatch of Mr. R. A. Marr, Acting Assistant, to Point Barrow, Alaska, in furtherance of the plans initiated during the preceding year, in virtue of which the Coast and Geodetic Survey co-operated with the Signal Service in establishing a station of the International Polar Commission at Point Barrow.

Having swung his pendulum and vibrated his magnet at the San Francisco station, selected by Assistant Davidson, Mr. Marr left San Francisco, June 16, 1883, on the schooner Leo, and on the 25th of July, reached Plover Bay, Eastern Siberia. Here he got a few pointings on the sun for time, and leaving on the 27th, the Leo ran along the Siberian coast north of East Cape, and then crossed to the American side to Point Hope and Cape Thompson. August 8, the first ice was sighted south of Icy Cape; on the 9th the vessel anchored off Wainwright Inlet near a portion of the whaling fleet, after trying to push through the ice and around Point Belcher. There was open water beyond the Sea Horse Islands. The ice-pack proper was distinctly visible from the anchorage, and formed apparently like that laid down on the chart for "July, 1849." The whalers had followed the ice from Behring's Straits, and reported a severe season since entering the Arctic. The Leo was continually shifting position to avoid ice-floes moving to northeast. At times there was a two-knot current, and once ice was noticed moving against a light wind. Several attempts were made to get around Point Belcher; two small schooners succeeded in finding an opening. Mr. Marr went ashore several times with a view of establishing a station at Point Belcher, should the vessel be unable to get through the ice.

August 20 Lieutenant Ray of the Signal Service, commanding the expedition, reported open water off Sea Horse Islands, and no shore ice off Ooglaamie, Point Barrow. August 22, the vessel was anchored off Ooglaamie.

Between the 22d and 25th, having overcome the various difficulties presented by heavy surf and the closing in of the shore ice, Mr. Marr effected a landing with his instruments and outfit, and, having availed himself of a building placed at his disposal by Lieutenant Ray, built a pier for the pendulum stand, mounted his chronograph, and expected to begin observations on the morning of the 27th.

But the conditions of the ice and weather on that day, together with an accident to the vessel, led Lieutenant Ray to decide upon an immediate abandonment of the station, and as he did not deem it safe that Mr. Marr should remain with but one man during the winter, the latter was compelled, though very reluctantly, to give up the attempt to make the desired observations. Two or three days more, or until September 1, at the latest, would have enabled him to get the pendulum swings needed for comparison with those at San Francisco. Mr. Marr reports that after leaving Point Barrow, they did not pass any ice, and that they had good weather.

On the return voyage, observations for magnetic declination and horizontal force were made on two days at Oonalashka.

Mr. Marr has expressed his willingness to remain through the winter at Point Barrow, should another opportunity offer of obtaining the needed observations. He acknowledges his indebtedness to Mr. A. D. Schindler, who accompanied him on the expedition, for useful assistance.

After his return to San Francisco, in October, 1883, Mr. Marr made a full set of pendulum experiments, comprising eight swings of six hours each, extending througn two sets of twenty-four hours. Time was determined upon nine days by one hundred and four star transits, and four meridian passages of the sun.

Hydographic survey of the California coast between Salmon Point and Brushy Point.—Early in July, 1883, the hydrographic party on board the steamer McArthur, Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, commanding, was at Little River, Cal., in readiness to begin a hydrographic survey of the coast in that vicinity.

Tidal observations to obtain a plane of reference for the soundings were made at Little River from July 7 to November 17. Two projections on a scale of 1-20000 had been furnished to Lieutenant Taussig, covering the coast from Salmon Point to Brushy Point. Lines of sounding parallel to each other and normal to the coast were run to the limits of the sheets, from five to seven miles from shore, at distances apart of one-third of a mile to depths of fifty fathoms, and not more than double that distance apart beyond the fifty-fathom curve.

Lieutenant Taussig located all available anchorages (except Mendocino Harbor, already surveyed) and all buoys, chutes, and wharves within the limits of his survey. He has appended to his report a list of positions of sunken rocks and rocks awash determined by his party. He observes that in a swell the sea generally breaks on the outside rocks, but in a fog, and when the sea is smooth, the most dangerous rocks are without a sign of a breaker at times. Nearly all the rocks have growing kelp on them, and kelp is an invariable sign of a rocky bottom, but after heavy gales the kelp is sometimes broken off so as not to be noticeable.

Lieutenant Taussig's report is exceedingly full in all details of information that will be of service to the navigator on a coast where so few good harbors can be found. The dangers to be avoided are carefully described, the characteristics of the several anchorages are given, and the report will be a valuable contribution to the material for the forthcoming new edition of the Coast Pilot of California, Oregon, and Washington Territory.

He expresses his special indebtedness to Capt. John Van Helms, of the Pacific Coast Navigation Company, for nearly all of the hydrographic information that he obtained on the coast, and states that wherever he had opportunities of testing it, he found it absolutely correct.

With regard to the weather, Lieutenant Taussig remarks that during the summer months the coast was generally enveloped in a thick fog, at times changing to a misty haze that permitted of work close inshore. During July and August the sun was out with a clear sky but twice from the ship, while a mile inshore, clear warm weather prevailed nearly every day. The fogs hug the coast and do not as a rule extend far at sea, and less frequently do they go more than a mile or two inland. The strong northwest wind which is generally encountered along the coast after 11 a. m. seldom came home to drive away the fog. These northwest winds are strongest in April and May, grow less frequent during the summer and fall, and are rare in the winter when the southeast gales prevail, which are then severe, and are generally followed by strong winds from northwest, after which there is an interval of clear pleasant weather with light winds and smooth seas. Although during the summer there was not often a strong northwest wind *on* the coast, this wind prevailed *off* the coast and a heavy swell was the rule near shore, even when there was little or no wind. The southeast winds begin in the fall; are generally strong and are accompanied by heavy rains. After a southeaster, especially if there is an interval of calm, a heavy southwest swell rolls in, which generally results in some disasters on the coast. The whole coast becomes a line of breakers, and the seas frequently break in ten fathoms of water across the entrances to all the anchorages within the limits surveyed during the season. In many places, if vessels are caught in a southeaster, it is the rule to take the mooring chain on board, take a turn round the mast and windlass, get out all the head, stern, and quarter lines the schooner may have to the different buoys, and then all the hatches having been battened down, the crew leave the vessel, to return after the gale, if the schooner is still in existence.

With regard to the general set of the current along the coast, Lieutenant Taussig remarks that it was to the southeast, but its strength was so variable, and the set was at times so unexpectedly changed to northwest that it was impossible to formulate any results from general observations.

The officers attached to the party were Lieuts. J. B. Milton and E. P. Elliott, U. S. N., and Ensign P. B. Bibb, U. S. N. Lieutenant Elliott was detached, without a relief, on August 30.

Following are the statistics of the season:

Miles run in sounding	760
Angles measured	3,817
Number of soundings	13,265

Coast hydrography executed by the party of Lieutenant Taussig to the southward of the locality just referred to, and later in the fiscal year, has been mentioned already under a previous heading in this section.

SECTION XI.

OREGON AND WASHINGTON TERRITORY, INCLUDING COAST, INTERIOR BAYS, PORTS, AND RIVERS.

(SKETCHES Nos. 2, 12, AND 13.)

Survey of Siuslaw River entrance, and continuation of the triangulation and topography of Umpquah River, Oreg.—Instructions issued to Assistant Louis A. Sengteller soon after the beginning of the fiscal year directed him to take charge of the schooner Yukon, then laid up at the Mare Island navy-yard, Cal., and, after fitting her for sea-service, to organize a party for a topographic and hydrographic reconnaissance of the Siuslaw River, and for the continuation of the triangulation and topography of the Umpquah River, Oreg.

On July 21, repairs having been made and outfit completed, the Yukon was dispatched to sea, in charge of the sailing-master, who had received orders from Mr. Sengteller to enter Siuslaw River and pass out again in the Yukon if he should find it practicable to do so; and if not, to make sail for Umpquah River entrance. Owing to a succession of calms, alternating with very high head winds, the vessel made but slow progress. August 13, with a light but fair wind, the Yukon ran close in to shore in the vicinity of Siuslaw River, but could find nothing that would serve to identify the entrance, and as heavy fog began to drift in, the schooner was put to sea, and a course steered for Umpquah River, which was reached and the bar crossed August 15.

Plans were then arranged by Mr. Sengteller (who had remained at Umpquah River), to dispatch a surf-boat, with crew and provisions, by sea to Siuslaw River; the boat arrived and crossed the bar without mishap August 18, and the next day Mr. Sengteller, who had proceeded overland, began his reconnaissance. A site for a base line having been selected, and triangulation stations located, the base was measured, and enough points having been determined in position, the topography and hydrography were begun August 23 and continued until the shore-line of the river, the topography adjacent and the soundings, had been completed from the entrance to the village of Florence, a settlement about five miles from the coast. Such examinations of the bar and of its approaches as the weather permitted were made also. A beacon was erected, plainly visible from the bar, as a range mark for vessels attempting to enter Siuslaw River.

Mr. Sengteller states, as a result of his examinations, that no definite sailing directions can be given for entering the river, owing to "possible constant shifting of the bar," and that on nearing the bar a vessel should not approach nearer than five fathoms. Then, by bringing the beacon on the north bank of the river to bear north 75° east (magnetic), and about one nautical mile distant from the mast-head and in smooth water, the best water for crossing can only be located by an occasional lull in the breakers. When these are at all rough, only a continuous line of surf is visible, and at such times it is dangerous to attempt an entrance.

He recommends a buoy for marking the approach to the bar as given by the bearings to the beacon—a large can buoy to be dropped in not less than ten fathoms of water. To obtain with the least loss of time an authentic knowledge of entrances of this character along the coast of Oregon, and to meet the demands of a rapidly-growing section of the coast for greater facilities of transportation seaward, he suggests that a light-draught steamer would be extremely serviceable.

Following are the statistics of the work at Siuslaw River, which was completed September 6:

Miles of shore-line surveyed	13
Area of survey in square miles	4
Miles run in sounding	31
Angles measured	684
Number of soundings	2,692

Arrangements were then made by Mr. Sengteller for resuming the triangulation and topography of the Umpquah River. On September 7 he proceeded thither in the Yukon, leaving his sailing master with a boat's crew at the Siuslaw with instructions to cross the bar and join him at the Umpquah at the first favorable opportunity. Owing to unfavorable weather and the condition of the bar at Siuslaw River entrance, it eventually became necessary to transport the boat and crew overland. Although progress was somewhat impeded by the absence of the crew, who did not return to the Umpquah till September 28, operations were pushed forward as rapidly as practicable, and the party continued in the field until October 6, when the funds available for the work were exhausted. On the 11th of that month the Yukon left for San Francisco.

Following is a summary of the statistics of the Umpquah River work:

Positions determined in the triangulation	7
Number of observations made	1,116
Miles of shore-line surveyed	3
Area of topography in square miles	3

Survey of Nestucca Bay and River, Oreg., and continuation of the triangulation and topography of the Willamette River, and of the topography of the Columbia River.—In compliance with instructions received early in July, 1883, Assistant Cleveland Rockwell left Portland, Oreg., July 12, and on arriving at Nestucca Bay immediately organized a party for the survey of that bay and of the Big and Little Nestucca Rivers, by the junction of which it is formed. A base was measured, signals erected at the points selected for stations of the triangulation, and a tide-gauge established to obtain a plane of reference for the soundings. Three days sufficed to finish the soundings inside of the entrance, as at low water the area is nearly covered by sand and mud flats, and was surveyed with the plane-table.

The triangulation and topography were carefully executed, as forming part of the general coast work, and the survey was completed September 27.

Mr. Rockwell remarks that the character of the country is mostly rolling and steep hills which have been long denuded of timber and are now covered by fern and grass.

Forest fires since the settlement of the country by the whites have swept over the whole area from the coast back to the Willamette Valley, and the coast range of mountains presents from the ocean a desolate array of tall and bare white stumps and trees.

He observes also that there is every evidence that in former times the Big Nestucca entered the ocean opposite Haystack Rock, but the drifting sand filled in the coast line, forming the long sand peninsula to the north of the entrance, and pushing the entrance to the two rivers down towards the rocky bluff to the south.

Upon the bar there were continued breakers. Having no suitable boat or crew it was not practicable to make an examination of the bar. The heavy swell from the southwest which set in during the middle and latter part of August closed the bar nearly up, so that at low water, on viewing it from the bluff, the white water would roll across for a hundred yards or so. Shoal water extends a long distance outside, as shown by the heavy rollers.

About the middle of October Mr. Rockwell was directed to take up the tertiary triangulation of the Willamette River from its mouth up to Portland. This work had been begun in 1882. Field operations were carried on till December 15, at which date all necessary third order points for the topography and hydrography of the Willamette from its mouth up to and beyond the city of Port-

land, Oreg., had been established. The sloop Kincheloe was used as a means of transportation. For this work Mr. Rockwell has furnished the following statistics:

Number of stations occupied	16
Number of angles measured	91
Number of points determined	27
Number of observations made	2,234

During the remainder of the winter and the spring Mr. Rockwell was engaged upon office-work, and in May, 1884, he was instructed to resume the topographical survey of the Columbia and Willamette Rivers. For a short time he was engaged upon the low shores of the two rivers, but as the water steadily rose, covering all the shore-line and interior topography, he moved the vessel up the Willamette, and took up work on such parts of the country as were above water, being obliged to leave the delineation of the actual shore-line until the water should subside.

At the end of the fiscal year he was prosecuting the survey near the city of Portland.

Hydrographic surveys of Gray's Harbor and in the vicinity of Seabeck, W. T.—As stated in my last annual report, a hydrographic survey of Gray's Harbor, W. T., had been begun before the close of the fiscal year by the party in charge of Lieut. T. Dix Bolles, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Earnest.

Some difficulty was experienced in fixing a tide-gauge, three having been washed away in succession, owing to the extensive mud flats and strong, rushing currents. One was finally established in South Bay, near the entrance. This was a plain staff-gauge, and was observed day and night for a lunar month. As the plane of reference for soundings the mean of the five lowest low waters was taken. A secondary tide-staff was set up at Hoquiam, and the plane of reference for the upper bay was computed by the Coast Survey rules for water levels. A bench-mark was established on Nettle Island, in South Bay, fourteen feet and eight-tenths above the plane of reference.

In regard to the locality of the work the following details are given in the reports of Lieutenant Bolles and Ensign Jordan, who succeeded him in charge of the party:

The inside harbor consists of an extensive mud and sand flat, with a channel running up the middle to the Hoquiam and Chehalis Rivers, and an arm extending into North and South Bays, near the entrance. From each of these, numerous blind sloughs lead off into the flats. The three channels have from three and a half to eight fathoms in the lower bay, gradually shoaling to from nine to twelve feet as they extend north, east, and south. There is another channel from the Chehalis River, on the south side of the bay, but a sand-bar at the mouth prevents more than five or six feet being carried into it.

The bar outside is from three to four miles off shore, with ten feet on it at low water. Extensive shoals make off from the north and south sides of the entrance, and are distinctly marked by breakers even with a moderate sea. The water deepens inside the bar to eighteen fathoms between the points. There is a very strong current during the ebb and flow of the tide, and an ugly chop sea at the entrance during the ebb, making it very dangerous work for a boat. During the summer months the northwest winds blow steadily every afternoon, and the northwest swell breaks clear across the bar. There are but few places on the shore where a landing can be made at low water, on account of very soft mud flats extending off from one-third of a mile to over three miles.

Two hydrographic sheets were completed each on a scale of 1–20000, extending from the mouth of the Chehalis River to four miles off shore, and including the whole of Gray's Harbor and Bar. The statistics of the work, which was closed October 15, are as follows:

Miles run in sounding	219
Angles measured	1,162
Number of soundings	6,115

Ensign J. N. Jordan, U. S. N., was attached to the party during the season. Ensign J. L. Purcell reported for duty on board the Earnest September 19. Upon closing work in October, the schooner was laid up for the winter at the head of Port Townsend Bay. Lieutenant Bolles was detached January 30, 1884.

In May, instructions were received by Ensign Jordan to take charge of the vessel, and after completing the necessary preliminary arrangements, to begin a hydrographic survey in the vicinity of Seabeck on Hood's Canal, W. T.

The Earnest with the steam-launch Tarry-not arrived at Seabeck June 3. A tide-gauge was soon after set up in Seabeck Harbor, on the west side, and observations were in progress at the close of the fiscal year. At that time the survey was advancing, soundings having been begun June 12.

Ensign Jordan has furnished the following statistics of this work to the close of the fiscal year:

Miles run in sounding	100
Angles measured	849
Number of soundings	3, 449

Continuation of the topographical survey of Hood's Canal, W. T.—In July, 1883, Assistant J. J. Gilbert, who was then at San Francisco, attached to the party of Assistant Davidson, received instructions detaching him from duty there and directing him to resume the topographical survey of Hood's Canal, W. T.

On arriving at Olympia he took charge of the steam-launch Fuca, and left at once for Hood's Canal, on reaching which he established his camp in the village of Seabeck as a base of operations.

During July and most of August Mr. Gilbert reports that progress was greatly impeded by the unusually dense smoke from the forest fires. After the rains of late August and early September had cleared the atmosphere, the weather continued very favorable for work until about the middle of November, when the winter rains set in. On November 19, the weather being stormy, with a prospect of continuing so for an indefinite period, field operations were closed. After some needed repairs the Fuca was laid up at Port Townsend.

During the winter and early spring Mr. Gilbert was at work upon his plane-table sheets, five in number. Tracings of these were forwarded to Washington March 10, and the sheets themselves April 15.

Finding that the allotment of funds as yet unexpended would enable him to take the field early in May, he left Olympia May 5, stopping on the way at Tacoma for coal for the launch, and at Seattle for coal and outfit. Camp was established at Union City, and field work begun May 15.

One week in May was devoted to triangulation. With that exception, the two field seasons during the fiscal year were occupied with topography. During May and the early part of June the weather was very favorable, but the last two weeks in June were unusually stormy.

The shore-line and topography, at the close of the fiscal year, had been extended from station Drift, on the east side of Hood's Canal, and from station Rock II, on the west side, to station Arrow on the east and station Windfall on the west, including all of Dabop and Qualcine Bays. Contours, as is unavoidable on these shores, are principally sketched, but the sketching is assisted wherever practicable by running a line of contours straight back from the shore-line. All logging roads were taken advantage of for this purpose, and additional lines run at intervals wherever the forest was not too dense to be penetrated.

Two additional topographic sheets were in hand at the close of the fiscal year, making seven sheets in all.

The statistics furnished by Mr. Gilbert are as follows:

Number of stations occupied in the triangulation	9
Number of observations made (6 repetitions each)	142
Miles of shore-line surveyed	117
Miles of roads	42
Area of topography in square miles	37

The present working season will complete the topography of the canal, and will also, if it is found feasible, make the connection with the head of Case's Inlet.

Continuation of the triangulation and topography of Possession Sound, W. T.—In compliance with instructions issued in April, 1884, Subassistant J. F. Pratt proceeded to San Francisco, Cal., and

upon his arrival there, toward the end of that month, took charge of the schooner Yukon to prepare her for service on Possession Sound. The needed repairs having been completed, the Yukon sailed from San Francisco May 14, and arrived at Seattle, W. T., May 28, and a few days later was in Possession Sound.

The month of June was occupied by Mr. Pratt in a reconnaissance, the erection of signals and the occupation of stations for the triangulation of the sound. Eight stations had been occupied by the end of the month, and observations were still in progress at the close of the fiscal year. A full statement of the work accomplished during the season is necessarily deferred till my next annual report. Other duty executed by Mr. Pratt is referred to under the heading of Section XIII.

Triangulation and topography of the Strait of Fuca.—Early in June, 1884, Assistant B. A. Colonna arrived at Port Townsend, W. T., in pursuance of instructions directing him to execute the triangulation and topography of the Strait of Fuca. After familiarizing himself with the locality, he had well advanced the preparations needed to take up the work by the end of the year with which this report closes.

Duty on the Atlantic coast which had been assigned to Mr. Colonna earlier in the fiscal year is referred to under the heading of Section VI.

Hydrographic survey of the Strait of Fuca.—The steamer Hassler which had been in service for some years on the coasts of Alaska, and had been laid up for repairs at the Mare Island navy-yard during the winter of 1883–'84, was placed under the command of Lieut. Commander A. S. Snow, U. S. N., in the spring of 1884, and that officer was directed to organize a party for the hydrographic survey of the Strait of Juan de Fuca.

The Hassler left San Francisco May 16, 1884, and arrived at Esquimault, British Columbia, May 21. Having taken in coal at Departure Bay, and made other needful preparations for the work, soundings were begun in the strait June 5, lines being run across it at intervals of two miles, and in depths varying from ten to one hundred and twelve fathoms. At the date at which this report closes a sufficient number of lines had not been run to justify any statements respecting the hydrographic characteristics of the locality. Work was being pushed at every opportunity of favorable weather, the sheet in hand, on a scale of 1-80000, including an area extending from Whitbey Island to Pillar Point.

The mean of lower low waters was adopted as a plane of reference for the soundings, to obtain which, observations of tides to be continued through one lunation were begun June 18, on a staff gauge established at New Dungeness. A similar gauge will be established at Port Angelos. To June 30, 1884, the statistics are:

Miles run in sounding	112
Angles measured	486
Number of soundings	467
Specimens of bottom preserved	24

The officers attached to the party were Lieut. G. Blocklinger, U. S. N., and Ensigns W. V. Bronaugh, F. H. Bostwick, and W. P. White, U. S. N.

SECTION XII.

ALASKA, INCLUDING THE COAST AND ALEUTIAN ISLANDS. (SKETCH No. 14.)

Hydrographic reconnaissance of the bays and harbors of Southeastern Alaska, continued.—At the beginning of the fiscal year, as mentioned in my last annual report, the surveys of the bays and harbors of Southeastern Alaska were being continued by Lieut. Commander H. E. Nichols, U. S. N., Assistant Coast and Geodetic Survey, in charge of the hydrographic party on board the steamer Hassler.

Lieutenant-Commander Nichols arrived in the Hassler at Port Simpson, May 16, 1883, and continued his surveys until October 13 of that year, when the steamer left Port Simpson for San Francisco.

The results of his work are shown upon six hydrographic sheets, all of which, with the records accompanying, have been transmitted to the office.

These six sheets include the hydrography of the following localities in Southeastern Alaska: Cape Fox to Tree Point, Port Tongass, Port Chester, Tamgas Harbor, Cape Fox to Bold Island, May Island to Point Higgins.

They will form the basis of charts of those localities, arrangements for the early publication of which are now being made.

Lieutenant-Commander Nichols remained in command of the Hassler till March 6, 1884, when he was relieved by Lieut. Commander A. S. Snow. In the surveys of 1883 he was aided by the following-named officers: Lieut. G. Blocklinger, U. S. N., and Ensigns W. V. Bronaugh, F. M. Bostwick, J. H. Fillmore, and W. P. White, U. S. N. Mr. Fremont Morse, Aid in the Survey, served as astronomer to the party, and in a manner which called forth special commendation from his commanding officer. Mr. Morse was detached and ordered to other duty in December, 1883.

Tidal observations with self-registering tide-gauge continued at Saint Paul, Kadiak Island, Alaska.—The tidal records of Saint Paul, on the island of Kadiak, Alaska, have been well kept up, with no stoppage, except from a change made in the location of the pier. Mr. W. J. Fisher was, as heretofore the observer. The self-registering gauge is on a wharf, recently rebuilt, of the Alaska Commercial Comp ny. The earthquake waves from the upheaval at Krakatoa in August, 1883, were registered on this gauge, as well as the one at Saucelito, San Francisco Bay entrance.

Expedition to Point Barrow, Alaska, for the purpose of determining gravity and the magnetic elements.—An account has already been given under the heading of Section X in this report of the results of the attempt made by Mr. R. A. Marr, Acting Assistant, to make determinations of gravity and the magnetic elements at Point Barrow, Alaska, in execution of instructions issued in May, 1883, and in connection with similar determinations made in San Francisco.

Although from circumstances entirely beyond his control, and at a time when all preparations for the observations had been completed, Mr. Marr was obliged to leave Point Barrow without obtaining them, it is hoped that a future effort, made under more favorable auspices, will be successful.

SECTION XIII.

KENTUCKY AND TENNESSEE. (SKETCHES Nos. 1, 4, 6, 15, AND 19.)

Occupation of the longitude station at Louisville, Ky., for the determination of the longitudes of stations in Tennessee, Kentucky, West Virginia, Indiana, and Illinois by exchanges of telegraphic-signals. Observations for latitude at stations not before determined.—At the beginning of the fiscal year the longitude parties under the direction of Assistant G. W. Dean and Subassistant F. H. Parsons were occupying stations at Louisville, Ky., and Jellico, Tenn.; the station at Louisville being the point of reference for a series of longitude determinations to be made by Subassistants Parsons and Sinclair, in co-operation with Assistant Dean.

At Jellico, Tenn., an astronomical station was established by Mr. Parsons, and connected with one of the mile-stones in the boundary line of Kentucky and Tennessee. Longitude signals were exchanged with the party of Mr. Dean at Louisville on the nights of July 1, 2, and 3; latitude observations were also made on those nights.

The next station occupied by Mr. Parsons was one at Richmond, Ky., in the grounds of the Kentucky Central College, which was identical with the station occupied some years ago by Professor Page in reconnaissance for triangulation. Longitude signals were exchanged with Louisville on July 9, 17, and 18. An intended exchange on the 19th was prevented by the general strike of the Western Union telegraph operators. Observations for latitude were made on six nights between the 7th and 19th of July.

It being apparent that the interruption occasioned by the strike would continue for some time, Mr. Parsons proceeded to Louisville, and observed there for personal equation with Mr. Carlisle Terry, jr., Aid in the Survey, who was attached to Mr. Dean's party, and by whom the observations at Louisville were made.

Before the personal-equation work had begun, however, Mr. Dean's party exchanged signals

for longitude on July 17 and 18 with Subassistant C. H. Sinclair, at Smith's Ferry, Beaver County, Pa. This determination was required in the course of the survey of the boundary line between the States of Pennsylvania and West Virginia, as referred to in this report under the headings of Sections II and III. Signals were again exchanged with Mr. Sinclair, after the termination of the strike, on August 13.

At that date, the observations for personal equation having been completed at Louisville, and some office work accomplished, Mr. Parsons proceeded to Charleston, W. Va., and occupied the station erected there in the grounds of the State capitol building in 1881.

This station was taken as a primary one, and after five exchanges of longitude signals had been obtained on as many different nights between August 16 and August 25 with the Louisville station, the observers changed places, Mr. Parsons proceeding to Louisville, and Mr. Terry going to Charleston. A second series of exchanges was obtained on six nights between August 29 and September 5, completing this longitude determination. The latitude of the station was determined by observations on six nights with zenith telescope No. 6, Mr. Parsons observing on three nights and Mr. Terry on three.

The next station (a secondary one) was established by Mr. Parsons about the middle of September at Logansport, Cass County, Ind., in the grounds of the High School. Longitude signals were exchanged with Louisville on three nights between September 14 and 20, and latitude was observed on five nights between September 13 and 19.

On the 11th of September Mr. Dean left Louisville for Chicago under instructions to establish a primary astronomical station in the latter city.

Mr. Dean acknowledges his many obligations to the Rev. Dr. Galusha Anderson, president of the Chicago University, by whose kindness and friendly co-operation permission was granted for the erection of an astronomical station in the grounds of the University. Also to Prof. G. W. Hough, director of the Dearborn Observatory, who gave every facility in his power towards the prosecution of the work. With his approval, the pier for the transit instrument of the Coast and Geodetic Station was established in the meridian of the transit circle of the observatory, and at a distance of 33.87 meters to the north of the center of that instrument.

On the 21st of September, the field observatory having been completed, Mr. Parsons with his party and instruments arrived from Logansport. On the following day Mr. Carl Schenk, Acting Assistant, arrived from Louisville. Mr. Schenk had been attached to Mr. Dean's party since the 25th of July, and had been engaged at every favorable opportunity in making latitude and time observations. At Chicago he measured a suitable base near the university buildings and made several series of measurements of horizontal angles for the purpose of referring the center of transit instrument at the station to the center of the dome of the Dearborn Observatory, and to other prominent points on the university buildings.

For longitude, signals were exchanged between Mr. Parsons at Chicago and Mr. Terry at Louisville on six nights between September 25 and October 29. The entire month of October proved to be very unfavorable for observations. Latitude was observed at Chicago by Mr. Parsons on seven nights between September 25 and October 19.

On October 30 the observers at Louisville and Chicago changed places, and, in their new positions, signals for longitude were exchanged on five nights between October 31 and November 11. With this longitude determination, field operations were closed for the season.

Messrs. Dean and Parsons express their official acknowledgments for many courtesies and cordial assistance received from the district superintendents of the Western Union Telegraph Company at Louisville, Chicago, and other points of their operations. Similar acknowledgment is made by Mr. Parsons to General W. H. Smith, vice-president of the Louisville and Nashville Railroad, and to the officers of that company; to President Patterson of the Kentucky Agricultural and Mechanical College at Lexington, Ky.; to President Logan of the Kentucky Central College at Richmond, Ky., and to Prof. G. W. Hough of the Dearborn Observatory and Prof. J. K. Watts, superintendent public schools at Logansport, Ind.

Mr. J. W. G. Atkins served acceptably as Acting Aid in Mr. Parsons's party. The records and field computations of both parties have been transmitted to the office.

Extension of reconnaissance and triangulation in the State of Kentucky.—In accordance with

instructions received in July, 1883, Subassistant J. F. Pratt proceeded to Louisville, Ky., and took up the work begun there by Assistant G. A. Fairfield in 1879, and continued during parts of the years 1880, 1881, and 1882, by Acting Assistant Carl Schenk.

Mr. Pratt reached the working ground July 24, and having organized his party, began operations by visiting stations Bangs, Williams, and Potts, on the Indiana border, and Riley and Mount Top in Kentucky, in order to familiarize himself with the country and place the signals in adjustment.

The preliminary examination developed the following characteristics of the section of the State from Louisville to Lebanon over which the triangulation was ultimately carried. Along the eastern side of Hardin and La Rue and the northern side of Taylor Counties runs a long continuous ridge called Muldraugh's Hill, which from the east appears as a range of hills, but is practically a plateau, the greater portion of which is covered with a large growth of timber. East of Muldraugh's Hill, and extending as far east as the stations Riley, Jackson, White Lick, and Rohan (see sketch No. 15), the country is covered with timbered "knobs" averaging about three hundred feet in elevation. East of these points and as far as station "Jeptha," the country is rather high and rolling, but practically, for the purposes of triangulation, it is flat.

The season was one of the driest known to the oldest inhabitants, and in consequence it was a very smoky one.

On account of the nearly equal height of the knobs and the dense timber covering them, the reconnaissance was very difficult, and had to be made almost entirely from the highest tree tops. It was carried over about one-half of the present scheme, and then the stations Riley, Mount Top, Dobbins, and Jackson were occupied. The reconnaissance was then extended to the points Pennick and Spurling, and eight more stations were occupied, the two last being Ferriell and Rohan.

Two tripod and scaffold signals were erected in the course of the work, one of twenty-three feet at Burkett, the other of forty-five feet at Spurling. Field operations were closed December 15. At that date the triangulation and reconnaissance had been carried over a distance of fifty miles from the starting point.

The statistics of the work are as follows:

Number of points visited in reconnaissance	55
Number of signals erected	18
Number of geographical positions determined	27
Number of angles measured	127
Number of stations observed upon	107
Number of single measures	2,558
Area in square miles covered during the season	555
Cost per square mile of reconnaissance and triangulation	$2.80

Other duty executed by Mr. Pratt is referred to under the headings of Sections III and XI.

Continuation of the triangulation of the State of Tennessee.—As stated in my last annual report, the party of Prof. A. H. Buchanan, Acting Assistant, was in the field at the beginning of the fiscal year, engaged in erecting signals in continuation of the triangulation of the State of Tennessee. During July and the first week in August, four signals were erected, viz, "Copper Ridge" in Meigs County, "Owen" in Monroe County, "Cockspur" in Blount County, and "Brushy" in Morgan County.

The season was so exceedingly unfavorable for observation by the smoky condition of the atmosphere that but one station was completed—Luper, eight and a half miles northwest of Rockwood. From this point nine stations were observed. Field operations were closed October 30. The statistics of the work are as follows:

Number of primary and secondary signals and other objects observed upon	39
Number of observations of horizontal angles	343
Number of observations of vertical angles	270

SECTION XIV.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN. (SKETCHES NOS. 1, 4, 15, 16, 17, AND 19.)

Occupation of stations for the extension of the triangulation of the State of Ohio.—The work of inspecting signals, and adjusting them in continuation of the triangulation of the State of Ohio, was begun early in July, 1883, by the party under the direction of Prof. R. S. Devol, Acting Assistant.

Observations of horizontal angles were begun at McDaniel station, in Hocking County, July 9. After some days' trial it was found that, although the lines of sight were comparatively short, ranging from seven to twenty-one or twenty-two miles, yet the condition of the atmosphere was such that heliotropes would be required for at least two of the stations.

These having been placed in position, more rapid progress was assured. On July 24, a temporary interruption of the work was occasioned by a storm which prevailed over a wide area, and was specially violent in a narrow track across Townsend Hill, where one of the signals had been erected. The tripod and scaffold at this station were blown to the ground. By July 28 they had been put up again, and observations were continued at McDaniel station till August 4, when the work there was finished.

The party was at once transferred to Townsend station, in Athens County, a few miles south of the town of Athens. At this point observations were begun August 6 and completed August 25, soon after which field operations were closed. All records and results of the work, including barometer readings for the approximate determination of heights, have been transmitted to the office. The statistics are as follows:

Number of angles measured	14
Number of measurements	950

Reconnaissance for the continuation of the triangulation of the State of Indiana.—The charge of the triangulation of the State of Indiana having been resumed by Prof. J. L. Campbell, in the winter of 1882–'83, as stated in my last annual report, he took the field for the continuation of the reconnaissance and triangulation in July, 1883. In the scheme of the work was involved the occupation of the stations "Sims" and "Bangs," the line joining which is the diagonal of a quadrilateral connecting with points in the survey of the State of Kentucky, and thus bringing these two State surveys into geodetic connection.

The month of July was occupied by Professor Campbell's party in the final determination of the site for "Sims" in Clark County, the northeast station of the first quadrilateral, and the erection of a tripod and tower at that station; the erection of a tripod and tower at the northeast station, "Six-Mile Switch," in Floyd County, and the establishment of permanent underground marks at both of those stations. In August and September observations were completed at stations "Sims" and "Bangs," and between the 1st and 10th of October, field operations having been closed for the season, Professor Campbell verified the results of his work, and transmitted them with his report to the office.

Special pains were taken in marking the two stations occupied to have both the underground and surface marks well secured. Descriptions of these markings accompany Professor Campbell's report.

In June, 1884, Professor Campbell began a reconnaissance for the extension of the triangulation northward from the limits of his work of the previous season. With reference to a proposed connection by odometer measurements with the railway system of Indiana, he reported in favor of beginning such measurements in the northern part of the State, where straight lines of from five to twenty miles in length could be had, and one of eighty miles long. Connection could be made with the Lake Survey triangulation at the town of Mishawaka, Saint Joseph County, and the work be carried over the railroads from South Bend. Professor Campbell deems it very important to establish a connection between the Coast and Geodetic Survey work in the State and its railroad system.

Continuation to the eastward of the primary triangulation in Illinois near the thirty-ninth parallel.—At the date at which this report begins, the primary triangulation in Illinois near the thirty-ninth

parallel had been advanced eastward by Assistant G. A. Fairfield, whose party had been in the field since the middle of May, 1883. Station "Sturgess," near Vandalia, had been occupied, and one of the stones marking the Third Principal Meridian of the General Land Survey had been connected with the triangulation. To make this connection, a base of more than a mile in length was twice measured with steel wire, and four secondary stations were occupied by Mr. Isaac Winston, Aid in the party.

At the beginning of the fiscal year the party was established at "Mound" station, near Altamont, Effingham County. Progress at this station was much interfered with by violent storms and heavy gales of wind, amounting in several instances to almost a tornado. A section of the party under Mr. Winston's directions was engaged during July and until the 10th of August in building tripod and scaffold signals in advance of the observing party. Three such signals were built during that time, one at "Island Creek" station, eighty feet high; one at "Lucas" station, seventy-five feet high, and one at "Newton" station, forty feet high.

On July 29, Assistant F. W. Perkins reported for duty, and remained attached to the party until October 30, when he was relieved, and left for Washington.

"Holtzhausen" station, about five miles southeast of Farina, Fayette County, was occupied between August 3 and 21. Camp was next moved to "Lucas" station, about ten miles east of Edgewood, Effingham County, where observations were begun August 26 and finished September 3. The next station occupied was "Island Creek," about twelve miles to the eastward of "Effingham," the county seat of Effingham County. Observations at this station were begun September 9 and completed September 25, when the party was transferred to station "Newton," about four miles south of the town of that name, in Jasper County. Preparations for observing were completed October 2. This being an astronomical station, observations for time, latitude, and azimuth were made, as well as those for horizontal direction. The observations for time and latitude were made by Mr. Perkins, and completed October 29. Mr. Fairfield, having finished the observations of horizontal direction, began those for time and azimuth October 30 and completed them November 6.

On the 9th of November, camp was moved to Denver station, about ten miles northwest of the town of Olney, Richland County, where observations were begun November 12. Some delay was caused at this station by the breaking of the signal light at Holtzhausen station, and by the necessity of opening a line between Denver and Lucas stations, and building a higher signal at "Island Creek." The work at Denver was finished December 2, and on the 12th field operations were closed, seven primary stations and four secondary having been occupied.

Assistant Fairfield has made special reference in his report to the value of the services rendered in the work by Assistant F. W. Perkins; he acknowledges also the ready and active co-operation of Mr. Isaac Winston, Aid in the party. Mr. J. L. Harper served acceptably as recorder.

The statistics of the season are as follows:

Number of tripod and scaffold signals erected	3
Number of primary stations occupied	7
Number of secondary stations occupied	4
Number of primary signal observed upon	12
Number of secondary objects observed upon	29
Number of observations for horizontal direction	3919
Number of nights of observation of latitude	8
Number of pairs of stars observed	109
Number of nights of observation for azimuth	6
Number of observations for azimuth	136
Number of stars observed for time	90

During the winter and spring of 1883–'84 Mr. Fairfield was engaged in completing the records and results of his work.

In accordance with a recommendation that he had made, the authorities of Fayette County,

Illinois, in which was located the base measured for connecting the triangulation with one of the principal meridians of the Land Survey, decided to mark the base ends permanently by suitable stone monuments. These monuments were furnished by the county, under the direction of the Board of Supervisors, and placed in position by the county engineer. In March, 1884, upon application made by a committee of the Board, Mr. Fairfield, with my approval, communicated to the Board the geographical positions of the monuments at North Base and South Base. These monuments will thus be of value as reference marks for future surveys.

In June, 1884, Mr. Fairfield took the field in order to make the necessary preparations for resuming the work at the earliest period that the appropriation for it should be available. During that month his party were occupied in building signals.

Determination of the longitude of Logansport, Ind., and of Chicago, Ill., by exchanges of telegraphic signals with Louisville, Ky. Observations, also, for the latitudes of Logansport and Chicago.—A full statement has already been made under the heading of Section XIII of the determinations of the longitudes of Logansport, Ind., and Chicago, Ill., by exchanges of telegraphic signals with a station at Louisville. The observations at Louisville were conducted by Assistant G. W. Dean, with the aid of Mr. Carlisle Terry, jr., observer in his party; those at Logansport were made by Subassistant F. H. Parsons, with the aid of Acting Assistant Carl Schenk. At Logansport and at Chicago Mr. Parsons determined the latitude of the stations of observation. During the Louisville-Chicago exchanges of longitude signals, the observers changed places to eliminate the effect of personal equation from the results for longitude, Mr. Parsons making the observations at Louisville and Mr. Terry those at Chicago. Further details are given under the heading just referred to.

Stations occupied in continuation of the triangulation of the State of Wisconsin.—The report of Prof. J. E. Davies, Acting Assistant, in charge of geodetic operations in the State of Wisconsin, makes special mention of the progress of the triangulation in the vicinity of the boundary line between the States of Wisconsin and Illinois, great interest being manifested in the true location of the parallel 42° 30′, which is prescribed by the constitution of the two States as the proper boundary between them. Especially is this interest shown in the city of Beloit, between stations "Clinton" and "Newark" of the triangulation. What is called the State line passes through the heart of the business portion of the city, actually dividing the freight station of the Northwestern Railway, so that a doorway is marked "Wisconsin" on one side and "Illinois" on the other.

A division of this sort leads not unfrequently, of course, to complicated legal difficulties, especially in dealing with the criminal classes, and emphasizes the necessity of an accurate definition and marking of the boundary.

As a preliminary step to the occupation of stations "Newark" and "Clinton," their distances from the accepted State line were carefully measured with steel tape. Extensive cutting was found necessary to clear the lines of sight from each station. While this was in progress, a reconnaissance was conducted by Professor Davies to determine the feasibility of extending the triangulation by determining the quadrilateral, Blue Mound, Wadham's Grove, Fayette, and Washington, and by the selection of a new station on the State line to the eastward of Clinton. For the location of this point of the scheme, and that of other points here referred to, see Sketch No. 16.

Three stations were occupied during the season—"Clinton," "Newark," Newark County; Mount Pleasant, Green County; and "Wadham's Grove," Stephenson County, Ill. The statistics of the work are:

Number of horizontal angles measured (primary)	38
Number of horizontal angles measured (secondary)	14
Number of vertical angles measured	10
Separate measurements of vertical angles	360
Separate measurements of horizontal angles	2,616

The records and computations of the work were forwarded to the office soon after its close in November, 1883.

SECTION XV.

MISSOURI, KANSAS, IOWA, NEBRASKA, MINNESOTA, AND DAKOTA. (SKETCHES Nos. 1, 2, AND 17.)

Occupation of stations for continuing to westward the primary triangulation in Missouri and Kansas, near the thirty-ninth parallel.—As stated in my last annual report, the party of Assistant F. D. Granger was in the field at the end of June, 1883, engaged in the occupation of the primary station Normal, Johnson County, Missouri. The point occupied, with the permission of the regents of the school was the top of the chimney of the State Normal School building, Warrensburg. Observations at "Normal" were finished July 2. Professor Osborne, to whose kindness and courtesy the party was much indebted, has made request, for the use of the school, to be supplied with the geographical position of the station, its elevation above the sea, and the distances and directions of all stations visible from it. This information, with my approval, has been furnished to Professor Osborne.

During the early part of the season, signals were erected at stations "Baker," "Chapel Hill," Thornton, Hutton Mound, and Bowler, points of the scheme approved for the extension of the work westward. (See Sketch No. 17.) The erection of so many signals was deemed advisable in order that the occupation of stations for the necessary angular measurements could be carried on uninterruptedly during the favorable season for observing, which in this section usually begins in June and continues into November.

Station "Caldwell," about sixteen miles south of Warrensburg, Johnson County, Mo., was next occupied. Camp was pitched in an open field near the signal, and observations were begun July 11 and finished July 19.

On the 24th of July, the party was transferred to station "Hutton Mound," about twelve miles southeast of Harrisonville, Cass County, Mo. This station derives its present name from its owner, Mr. Hutton, who lives half a mile to the westward, but in the days of the earlier settlers was known as the "Big Mound," and was one of the landmarks which guided the emigrants on their journeys westward. It rises about one hundred feet above the general level of the surrounding country, and although prominent because of its isolation, is less in elevation above the sea than any of the stations visible from it. At this station, the theodolite was mounted upon a tripod, eighteen feet above the ground. Observations at "Hutton Mound" were finished by August 15, and the party was then transferred to Fulton, about two miles east of Harrisonville, where observations were begun August 20. The theodolite at this station was elevated twenty-two feet above the ground. Station "Baker," near Kingsville, Johnson County, was next occupied, work having begun here September 11. This station is situated at the southern end of a chain of small hills, which begins near Knoxville and extends about fifteen miles in a northerly direction. Near the northeastern limit of these hills, and near the village of Chapel Hill, Lafayette County, station Chapel Hill, the next in order of occupation, is situated.

The observations at "Baker" having been finished September 28, "Chapel Hill" was occupied at the beginning of October. The theodolite was mounted upon the tripod of the signal at an elevation above the ground of fifty-four feet, this elevation being needed to clear two of the lines of sight over the tops of trees. Work at this station having been finished, the season closed with the occupation of "Thornton," a point situated about three and a half miles northward of Pleasant Hill, Cass County, where observations were made between October 23 and November 2.

Mr. Granger commends the efficient services of Messrs. J. E. McGrath and A. P. Barnard, who served as Aids in the party. Mr. McGrath made most of the observations of double zenith distances, and assisted in the measurement of horizontal directions. Mr. Barnard recorded the observations, and aided in the office-work.

The general statistics are as follows:

Number of signals erected	9
Number of objects observed (primary)	12
Number of objects observed (tertiary)	12
Number of stations occupied	7
Number of observations of horizontal directions	3,331
Number of observations of differences of zenith distances by micrometer	1,348
Number of observations of vertical angles	381

During the winter Mr. Granger completed the records and computations of his work, and in June, 1884, proceeded under instructions to the field to organize a party for the continuation of the triangulation westward.

SECTION XVI.

NEVADA, UTAH, COLORADO, ARIZONA, AND NEW MEXICO. (SKETCHES NOS. 1. 2, 17, AND 18.)

Occupation of stations in Nevada, and reconnaissance in Utah for the extension eastward of the primary triangulation near the thirty-ninth parallel.—At the beginning of the fiscal year, the party of Assistant William Eimbeck was engaged in a reconnaissance of the table mountains east of the Sevier River in Utah, known as the Wasatch Plateau, with a view of developing the extension of the primary triangulation near the thirty-ninth parallel from the line "Nebo–Beaver" eastward across the high plateaus of Central Utah.

It was necessary to carry out this reconnaissance before occupying further stations of the great hexagon, because preliminary examinations of the high plateau country in question the year before had shown that a quadrilateral with open diagonals was not only wholly impracticable, but that the very locality, the king summits of the Wasatch Plateau, where the central station of a polygonal figure had of necessity to be established, was shut off from view at Beaver station by the interposition of Belknap, a nearer and higher peak of the Tushar Mountains. The closer examinations at the Wasatch Plateau, and subsequent ones from several of the principal summits of the Tushar Mountains showed that the change in the location of the station "Beaver," as referred to in my last annual report, was unavoidable, and that there existed no other choice than to locate it upon Belknap. For even Delano, the king peak of the group, which, on account of its location would have yielded the most favorable figure, proved unavailing on account of intercepting "tables" upon the line to Wasatch.

The preliminary reconnaissance from Mount Nebo during the previous year, together with the thorough and exhaustive examinations this year in the Wasatch Plateau and Tushar Mountains, sufficed to determine upon the quadrilateral figure Nebo, Patmos Head, Mount Ellen, and Mount Belknap, as shown in progress sketch No. 18. This is, indeed, the only adequate figure obtainable by which the main chain of triangulation may be carried eastward from the long line "Nebo–Belknap."

The development of a single definite figure, as above described, was all that was contemplated in carrying on the reconnaissance. Hence, on completing the examinations at the Tushar Mountains, further reconnaissance work was suspended, and the party was transferred to Jeff. Davis Peak, the re-occupation of which was rendered necessary by the abandonment of "Beaver" station and the substitution for it of "Belknap." After a tedious and toilsome journey through two hundred miles of a desolate country, the party arrived at Lehman's Ranch, near the eastern base of Jeff. Davis Peak on the 19th of July, and at once began preparations for the ascent of the peak, which rises to a height of thirteen thousand one hundred feet. By the 26th of July camp was established at the summit.

Three days' observations would have sufficed to determine the difference in directions of the heliotropes at Beaver and Belknap, but owing to thunder-storms, which hung almost constantly over the peak, and the distant mountains as well, it was the 6th of August before all of the observations needed could be obtained. Mr. Eimbeck remarks that the trials of the ten days' life of the party among the clouds were more severe and dangerous than had been experienced for several years. The violence of the electric discharges, the thunder-claps, and the energy of the piping sound of the escaping electricity was not unfrequently so alarming that the party had to seek safety behind and under ledges of rock some distance below the summit of the peak, which was often struck by lightning. The tent occupied by the men was also struck, but fortunately at a time when no one was in it.

Pioche station, in Lincoln County, Nev., a mountain of 8,800 feet in height, was next occupied. This is the last station of the work within the borders of Nevada. Owing to delay in getting means of transportation from Lehman's Ranch, arising from the difficulty of hiring hands during the season of harvest, most of the month of August was occupied in the transfer of the party and

camp outfit to the summit of Pioche. The observations at Pioche were completed by the 1st of October, after which the party was disbanded, the instruments and camp outfit being transferred to Nephi, Utah, where they were stored for the winter.

The work of the season to the date just named includes, besides the usual observations of horizontal directions and vertical angles, together with the necessary meteorological observations, determinations of time, latitude, and azimuth, and a complete set of observations for magnetic declination, dip, and intensity. Occasion was taken also, especially when at Lehman's Ranch, to carry out local triangulations, connecting the State boundary between Nevada and Utah, and thereby the land surveys of those two States with the geodetic work. The station near Lehman's Ranch at which the Transit of Venus of 1882 was observed by Mr. Eimbeck was connected with the main triangulation at Jeff. Davis Peak and at Pioche. Special report will be made upon the results of the reduction of these local triangulations.

From Jeff. Davis Peak a new determination was made of the azimuths of the reference marks of Tres-Pinos and Snake Valley magnetic stations, as occupied during the previous season.

Having completed the arrangements at Nephi for storage, Mr. Eimbeck took up the reconnaissance for the location and connection of the proposed base-line in the vicinity of Salt Lake City and Mount Nebo, as authorized by instructions issued in October, 1883.

The month of November was chiefly occupied with examinations of the country in the vicinity of Nephi and Juab, in Salt Lake Valley, as well as along the line of the Denver and Rio Grande Railway, near the cities of Kaysville and Ogden. Owing to the lateness of the season, the snow being deep on the mountains and in the valleys, it was impracticable to make these examinations as exhaustive as was desirable, yet as far as made they were enough to show that suitable sites for base-lines, connecting adequately with the main chain of the thirty-ninth parallel triangulation could be located of a sufficient length, both in Juab Valley, near Mount Nebo, and in the vicinity of Salt Lake City. The reconnoitering work thus done included the provisional examination of four distinct sites for base-lines, together with such connecting schemes as the hurried survey of the surrounding country had shown to be possible, if not feasible.

Early in the summer of 1884 the reconnaissance was resumed, the examinations extending principally over the high mountains near Ogden, Salt Lake City, and Alta, the valley south and west of Salt Lake City, the Juab Valley, and the mountains south of Nebo and the town of Levan. As the result of these examinations a special report was submitted referring to two sites and their connecting schemes—the Juab and Salt Lake bases.

Mr. George F. Bird served acceptably as Aid in the party from the 22d of August till the 17th of November, when he was detached for other duty. Under Mr. Eimbeck's direction he assisted in the time and latitude observations, and occupied the stations at Nephi, Provo, and Salt Lake City for the determination of the magnetic elements.

With regard to the experiments instituted by Mr. Eimbeck for ascertaining the practicability of using the light of the moon for night-signaling in geodetic operations, he remarks that the results were so promising as to warrant the resumption of the experiments during the present season, when there will be opportunities of testing the effect of the light on much longer lines than was practicable last year.

SPECIAL OPERATIONS.

Charge of the construction of the Coast and Geodetic steamer Carlile P. Patterson.—In pursuance of the action of Congress authorizing the construction of a steamship for the survey of the Pacific coast and sounds, and making appropriation therefor in the sundry civil expenses act approved March 3, 1883, plans and specifications were prepared under the direction of Commander C. M. Chester, U. S. N., Hydrographic Inspector, Coast and Geodetic Survey.

Through the courtesy of Naval Constructor S. H. Pook, at the navy-yard, Washington, D. C., Mr. Frothingham, the draughtsman of his department, prepared the drawings and model with much credit to himself, and gave other valuable assistance.

On June 1, bids having been formally asked for, as prescribed by law, they were duly opened, and the contract for the construction of the vessel was awarded to the lowest bidder, Mr. James

D. Leary, of Brooklyn, N. Y. The contract was signed July 1, and Commander Chester was appointed inspector on the part of the Government, Lieut. Richardson Clover, U. S. N., and Passed Assistant Engineer, H. N. Stevenson, U. S. N., being assigned as his assistants.

Lieutenant Clover, who had been associated with Commander Chester in the preparation of the data, from the inception by the late Superintendent of the project of building a vessel especially adapted to the survey of Alaskan waters, was stationed at New York, taking the immediate charge of the work, and under his constant watchfulness nearly ever timber and bolt that went into the construction of the steamer received careful inspection. It is believed that the plan of having the officer upon whom was to rest the responsibility of commanding the vessel in her voyage to the Pacific appointed as the immediate supervisor of her construction, was fraught with good results to the Government, and that he acquitted himself with credit is well known.

Mr. Stevenson was located at Philadelphia, where the steamer's machinery was being made by Messrs. Neafie & Levy. This officer had also been associated with Commander Chester in planning the machinery, and, as her future engineer officer, was deeply interested in the careful construction of the motive power of the vessel.

This arrangement of duties left Commander Chester free to proceed from point to point where he was needed to decide questions of construction, and to see that all workmanship and material were of the best quality and satisfactory to the inspector.

The steamer, named the Carlile P. Patterson, after the late Superintendent, was launched January 15, 1884, and at the date at which this report closes had made two satisfactory trial trips, and was nearly fitted for her voyage to the Pacific coast.

Charge of the Coast and Geodetic Survey Exhibit at the Southern Exposition, Louisville, Ky.—The Southern Exposition, held at Louisville, Ky., in the summer and autumn of 1883, was, as a whole, principally illustrative of the manufacturing and agricultural interests of the country; but there were many fine commercial exhibits, and the display was national in its character, exhibits being centered there from all parts of the United States, and the following departments or bureaus of the Government being represented in addition to the Coast and Geodetic Survey, viz: The Geological Survey, the Signal Service, the National Museum, the Bureaus of Education and of Engraving and Printing, the Life-Saving Service, the Fish Commission, and the United States Mint at Philadelphia.

Assistant H. W. Blair, having been assigned to the charge of the exhibit made by this Survey left Washington for Louisville in the latter part of July.

In the arrangements for placing the instruments, charts, and other articles illustrating the methods and appliances of the Coast and Geodetic Survey, Mr. Blair expresses his great indebtedness for kindness shown and assistance rendered by Maj. J. M. Wright, the manager of the exposition, and by Prof. J. R. Procter, State geologist, who had general charge of the placing of the Government exhibits.

Mr. Blair remarks that to the general visitor the display made by the Government seemed to be one of the most attractive ones. That of the Coast and Geodetic Survey showed the principal instruments used in its geodetic, astronomical, topographic, hydrographic, and magnetic work, with illustrations of the results of the work by selections from the published charts, collections of the Annual Reports, Coast Pilots, and Tide Tables, and by a model of the basin of the Gulf of Mexico constructed in the office from the results of soundings made between 1876 and 1878. This model attracted special attention; applications for copies of it were made, and it had many visitors from schools and classes of advanced students.

For the exposition management Mr. Blair prepared a concise description of the articles forming the Coast and Geodetic Survey Exhibit, together with a short account of their use. This paper appears as Appendix No. 18.

At the close of the exposition two awards were made to the Survey; one a medal for the exhibit as a whole, and the other a diploma for the line-and-end comparator.

Comparisons of standards of weight and measure, and investigations relating to determinations of gravity.—The special investigations relating to determinations of gravity and to comparisons of standards, carried on in Great Britain and on the continent during the summer of 1883 by Assistant C. S. Peirce have been already referred to in Parts I and II of this report; in the former under the heading "Special Scientific Work," and in the latter under the heading of Section III.

With reference to the ratio of the meter to the yard, to obtain an exact value of which has been one of the objects kept in view during the course of his investigations, Mr. Peirce makes the following statement:

"The ratio of the meter to the yard is still a matter of considerable uncertainty. Kater's value of the meter, 39.3707 inches is universally regarded as too long. Clarke's, 39.3704 inches, though undoubtedly more nearly correct, is not founded upon an examination of sufficiently good meters. The value given by Prof. W. A. Rogers, 39.37027 inches, is probably the most correct, but may be in error by one or two ten thousands of an inch. The main difficulties of the determination are four:

"'1. To obtain a length known to be equal to a meter.

"'2. To compare quantities practically incommensurable.

"'3. To compare two bars, one of which is standard at the freezing point while the other is standard at 62° F.

"'4. To compare a line-measure with an end-measure.'

"As the amount in doubt is large as compared with the best measures of the length of the second's pendulum, we may obtain a value of the meter not unworthy of consideration by comparing the value of the seconds' pendulum at Kew as determined by Captain Heavyside in inches with the same value as determined in terms of the meter by myself. This gives for the meter 39.3700 inches. In order to obtain a better comparison, two reversible pendulums, made on the same pattern, one measuring a yard and the other a meter between the knife-edges, were swung simultaneously, each near its standard temperature at the Coast Survey Office. The pendulums were also interchanged so as to determine at the same time their coefficients of expansion.

Assuming that by this method a meter and a yard bar can be made which shall bear to each other a relation capable of the most accurate determination, it will still be important to devise a method by which a check can be kept upon the changes in length to which all bars are liable by molecular action. Mr. Peirce has accordingly devoted much attention to the spectrum meter—a meter constructed so as to be readily compared with the length of a wave of light.

Attendance of a delegate on the part of the Coast and Geodetic Survey at the International Geodetic Conference at Rome.—Shortly before the time fixed for the seventh annual conference of the International Geodesic Association at Rome, I received from General Ibanez, of Spain, the president of the conference, a letter expressing his urgent hope that American science would be represented at Rome by a delegate from the United States. In view of the international importance of fixing upon a meridian which should be employed as a common zero of longitude and standard of time-reckoning, and of the great desirability of having the opinions of men of science in the United States brought before the conference during its discussions of these subjects, I took the earliest opportunity to obtain from the Department its sanction to the appointment of Mr. R. D. Cutts, Assistant in charge of the office, as a delegate to the conference.

But short notice having been given, Mr. Cutts was able to reach Rome only on the morning of October 15, the first day of the session. Reference has been made in a preceding part of this report to the part taken by him in its deliberations, and to the resolutions which were finally adopted as embodying the conclusions of the conference.

The subsequent action of this Government upon the final resolution recommending an International Convention to be held at Washington, as proposed by the United States and advocated by its delegate, is well known.

Transportation of valuable standards of weight and measure from England to France.—Occasion having arisen for the transportation under responsible personal supervision of two important standards of weight and measure from the British Standards Office in London to the International Bureau of Weights and Measures at Breteuil, near Paris, advantage was taken of a contemplated visit to Europe of Dr. Thomas Craig, of the Johns Hopkins University, who had kindly offered to be of service to the Survey. Dr. Craig's former connection with the work has sufficed to keep up his strong interest in it.

Upon his arrival in London, early in June, he went to the Standards Office and there received the standard yard (Low-moor iron No. 57), and standard Arago platinum kilogram and transported

them to Paris, depositing them on the 9th of June at Sevres with the International Bureau of Weights and Measures. The yard was simply deposited for safe keeping during the summer, and the kilogram for comparison.

On leaving Paris, Dr. Craig stopped at Sevres and received the standards again, took them to Washington, and delivered them to the Bureau of Weights and Measures on September 3, 1884. Under his care every precaution was taken to protect the standards from concussion or injury from any cause whatever.

Tidal observations at Honolulu, Sandwich Islands.—The superintendent of the survey of the Sandwich Islands, W. D. Alexander, esq., has continued to transmit to this office the records from the self-registering tide-gauge loaned to him by the Coast and Geodetic Survey in June, 1877. Blank forms of reduction, and tidal rolls are also supplied to him. The series will have special value in the discussion of the tides of the Pacific, and their comparison with those recorded on the coasts of Mexico, California, Oregon, and Alaska.

COAST AND GEODETIC SURVEY OFFICE.

From the beginning of the fiscal year until early in October, 1883, the charge of the office was continued with Assistant Richard D. Cutts. Upon his departure for Europe to attend the conference of the International Geodetic Association at Rome, as a delegate on the part of the United States (reference to which has been made on pages 4, 6, 17, and 81 of this report), Assistant Cutts was relieved by Assistant Charles A. Schott, who was assigned to act for him during his absence. When Mr. Cutts returned, towards the close of November, he resumed charge of the office, but his health rapidly failed and on the 13th of December, after an illness of about a week, he died.

The suddenness of this event, and the great loss to the work involved in it, as well as its severance of strong personal friendships, occasioned deep and wide-spread regret. His associates on the Survey expressed their sense of his loss by resolutions and addresses at a meeting called for the purpose December 15. The proceedings of this meeting have been placed on record on pages 14 and 15 of this report.

Until a permanent assignment could be made, Assistant Schott was designated to take charge of the office. In January, 1884, Assistant Charles O. Boutelle was placed in charge, and entered upon his duties January 7. In his report of the office operations during the fiscal year, which appears as Appendix No. 4, Mr. Boutelle, who had served nearly forty years in field duty, ackowledges his indebtedness to the method, system, and order introduced by his predecessors in lightening his labors, and also the kindly aid afforded by those of long experience in office details.

Assistant Andrew Braid was on duty as executive officer in the office of the Assistant in charge until January, 1884, when he was transferred to the office of the Superintendent, and Assistant H. W. Blair, who had been on duty under the immediate direction of the Superintendent, was assigned in Mr. Braid's place.

The report of the Assistant in charge is accompanied by the reports of the chiefs of the several office divisions. It is worthy of note that although the demands for information from the records and results of the Survey, and requests for its publications have increased largely during the year, while no increase of force has been practicable in the office, nevertheless the extra labor required to comply with these demands promptly has been cheerfully given. The distribution of the charts has increased sixteen per cent. during the year, and in the electrotyping department, under the direction of Assistant Ogden, a larger amount of work has been done than in any previous year. This has been the case also in the engraving division, which, as well as the electrotyping and printing divisions, has remained under Mr. Ogden's direction.

Full reference is made in the report to improvements in methods and processes tending towards greater efficiency and economy in the field and office operations. A new set of projection tables based upon the Clarke spheroid and extending from the equator to the pole has been computed, and appears in Appendix No. 6.

At the request of the Commissioner of Agriculture a measurement has been undertaken, and partly completed, of the areas of salt and fresh marsh upon the Atlantic coast.

The interest aroused by the model of the basin of the Gulf of Mexico, which was exhibited

by Mr. Hilgard at the November meeting of the National Academy of Sciences, 1880, led the Superintendent to direct the construction of another one on the same scale, which includes in its limits not only the depths of the sea in the Gulf of Mexico and the Bay of North America,* but also a representation in relief of the islands in the approaches to the Gulf, the Bermuda group, and parts of the continent. On the north this model reaches to the Great Lakes, on the south to Cuba, and in an east and west direction from Halifax and St. Thomas to the Llanos Estacados at the base of the Rocky Mountains and the city of Mexico.

Its construction was intrusted to Messrs. A. and H. Lindenkohl, the former the chief draughtsman in the office. They had been associated in the construction of the model of the Gulf, and were familiar with the data needed for the larger work. The submarine part of this model is based almost entirely upon the recent soundings by the Coast and Geodetic Survey, though the Challenger soundings and those of the Fish Commission have also been taken as authority when needed. The construction of the orographic part was greatly facilitated by access to the manuscript of the Dictionary of Altitudes (since published), kindly accorded by Mr. Henry Gannett, of the Geological Survey.

The model was exhibited at the International Fisheries Exhibition in London; at the meeting in Washington of the National Academy of Sciences in April, 1884, and at the meeting in Philadelphia in September, 1884, of the American Association for the Advancement of Science. Upon each of these occasions it attracted great attention and received high commendation. Upon the two occasions last mentioned the Superintendent read a paper upon the structural features of the two great basins which are revealed by the model in so striking a manner. A description of it appears in Appendix No. 17.

It is proposed to exhibit it at the approaching World's Exposition at New Orleans.

In the progress of the Survey, some important questions have arisen in regard to the proper designation and orthography of geographical names. In many localities different names have been found in use for the same characteristic features; local authorities differ irreconcilably, and the origin of their differences is often obscure. Hence the need was long felt of an authoritative historical account of the progress of discovery and exploration on the coasts of the United States, by the aid of which aboriginal names might be traced to their source, true orthographies established, corruptions pointed out, and the names given by early discoverers referred to the best authorities.

In the Reports for 1855 and 1856, Professor A. D. Bache, then Superintendent, alluded at some length to this subject, and stated that he had availed himself of the visit to this country of a distinguished ethnographer, Dr. J. G. Kohl, to request him to prepare a complete historical statement of the discoveries and explorations on the Atlantic, Gulf, and Pacific coasts of the United States. Dr. Kohl had previously made an extensive collection of maps of discovery on this continent, and was peculiarly qualified by his studies and researches for the important work committed to his charge.

Abstracts of the papers of Dr. Kohl were published in the Coast Survey Reports for 1855 and 1856; his manuscripts and maps have been preserved for reference in the Archives. It is believed that the occasion has now arrived for the publication of these valuable historical memoirs. They appear in Appendix No. 19.

Reference was made in my last annual report to the work of Assistant W. H. Dall in the preparation for publication of a new edition of the Coast Pilot of Alaska. The first volume has now been published under the title "Pacific Coast Pilot, Alaska, Part I, Dixon Entrance to Yakutat Bay with the Inland Passage."

The manuscript of a new and enlarged edition of the Catalogue of Charts was prepared during the summer of 1884 by Assistant Blair, and revised for early publication.

Mr. W. B. Morgan has served with acceptance as Disbursing Agent of the Survey. He has had the aid of Mr. John W. Parsons as accountant and of Mr. V. J. Fagin as examiner.

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* This appellation was suggested by the Superintendent at the April meeting of the National Academy of Sciences, 1884, to designate that great embayment of the North Atlantic which lies west of a line drawn from Newfoundland through the Bermudas to Saint Thomas in the West Indies.

In the preparation of this report I have been aided by Assistant Edward Goodfellow. The clerical duties in my office have been performed by Messrs. W. B. Chilton and C. D. Gedney.

Respectfully submitted.

J. E. HILGARD,
Superintendent.

Hon. HUGH MCCULLOCH,
Secretary of the Treasury.

PART III.

APPENDICES.

APPENDIX No. 1.

Distribution of the parties of the Coast and Geodetic Survey upon the Atlantic, Gulf of Mexico, and Pacific coasts and the interior of the United States during the fiscal year 1883–'84.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I.				
Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island, including coast and seaports, bays and rivers.	No. 1	Triangulation	O. H. Tittmann, assistant	Triangulation of the coast of Maine, between West Quoddy Head and Cross Island. (See also Sections V and VIII.)
	2	Triangulation and topography.	C. H. Boyd, assistant; T. P. Borden, aid.	Triangulation and topography of Machias Bay and vicinity.
	3	Hydrography	Lieut. E. M. Hughes, U. S. N., assistant (part of season); Lieut. Commander A. S. Snow, U. S. N., assistant; Ensigns H. M. Witzel, T. M. Brumby, A. L. Hall and J. H. Hetherington, U. S. N.	Hydrographic surveys between Cross Island and Nash Island; in the vicinity of Moosabec Reach and in Muscongus Bay, coast of Maine. (See also Section XI.)
	4	Topography	Eugene Ellicott, assistant	Topographical surveys of Harrington River and of Chandler's River Bay, Maine. (See also Section III.)
	5	Hydrography	Lieut. E. D. F. Heald, U. S. N., assistant; Lieut. David Daniels, U. S. N.; Ensigns O. G. Dodge and Alfred Jeffries, U. S. N.	Completion of the hydrographic surveys of Narragugus Bay and River and of Pigeon Hill Bay, coast of Maine. (See also Section IX.)
	6	Topography	A. W. Longfellow, assistant; W. I. Vinal, assistant.	Topographical surveys between Gouldsborough and Frenchman's Bays, coast of Maine.
	7	Tidal observations	J. G. Spaulding	Series of tidal observations with self-registering tide-gauge continued, and meteorological observations recorded at Pulpit Cove, North Haven Island, Penobscot Bay.
	8	Hydrography	Lieut. J. E. Pillsbury, U. S. N., assistant.	Hydrographic examinations of Pemaquid and Outer Heron Island Ledges, coast of Maine. (See also Sections IV and V.)
	9	Geodetic	Prof. E. T. Quimby, acting assistant.	Continuation of the triangulation of the State of New Hampshire.
	10	Geodetic	Prof. V. G. Barbour, acting assistant.	Occupation of stations in connection with the triangulation of the State of Vermont.
	11	Hydrography	Charles Junken, acting assistant; W. I. Vinal, subassistant.	Examination of ledges in Lake Champlain.
	12	Reconnaissance	Charles O. Boutelle, assistant; J. B. Boutelle, extra observer.	Reconnaissance for the introduction of additional lines in the triangulation between the Fire Island, Massachusetts, and Epping Base-lines. (See also Section II.)
	13	Hydrography	Lieut. Commander W. H. Brownson U. S. N., assistant; Lieut. F. H. Crosby, U. S. N., assistant; Ensigns J. T. Newton, H. S. Knapp, E. Simpson, jr., and M. C. Gorgas, U. S. N.	Hydrographic examinations in Vineyard Sound, and resurvey of Monomoy Passage, Nantucket Shoals. (See also Section II.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I—Continued.	14	Special survey....	Henry L. Whiting, assistant......	Survey of Gay Head Cliffs to fix position of wrecked steamer.
	15	Tidal observations	....	Observations continued at Providence, R. I., with a self-registering tide-gauge loaned to the city engineer.
	16	Tidal observations	J. M. Conley......................	Continuation of observations with self-registering tide-gauge established on the breakwater, Block Island.
SECTION II. Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including coast, bays, and rivers.	No. 1	Topography	W. C. Hodgkins, subassistant; J. H. Turner, acting aid.	Topographic resurveys of Stonington, Conn., and vicinity; also of the coast of Connecticut in the vicinity of Saybrook and Lyme. (See also Section VIII.)
	2	Hydrography.....	Lieut. A. V. Wadhams, U. S. N., assistant; Ensigns T. D. Griffin, A. L. Hall, and W. C. Canfield, U. S. N.	Hydrographic resurveys of Fisher's Island Sound and its adjacent waters completed.
	3	Hydrography.....	Lieut. John T. Sullivan, U. S. N., assistant; Lieut. W. G. Cutler, U. S. N.; Ensigns E. N. Fisher and J. P. Parker, U. S. N.	Hydrographic resurveys of the eastern part of Long Island Sound and a portion of Block Island Sound.
	4	Hydrography.....	Lieut. Commander W. H. Brownson, U. S. N., assistant; Lieut. F. H. Crosby, U. S. N., assistant; Ensigns J. T. Norton, H. S. Knapp, E. Simpson, jr., and M. C. Gorgas, U. S. N.	Hydrographic work off Shagwong Point, Montauk; resurvey of Black Rock Harbor, Conn.; examinations for rocks and ledges in East River, N. Y. (See also Section I.)
	5	Topography and hydrography.	Charles Hosmer, assistant; Ensigns, R. P. Schwerin and D. P. Menefee, U. S. N.	Topographic and hydrographic resurveys in the vicinity of Montauk Point, Gardiner's Bay, and Orient Harbor, Long Island; also completion of hydrography between Stepping Stones light-house and College Point, East River. (See also Section VIII.)
	6	Tidal observations	E. Koch	Completion of observations with self-registering tide-gauge at Fort Trumbull, New London, Conn.
	7	Topography.......	W. H. Dennis, assistant; E. L. Taney, aid.	Topographic resurveys of the north shore of Long Island Sound between New London and Four-Mile River and between Saybrook and Clinton.
	8	Hydrography	Lieut. John D. Keeler, U. S. N., assistant; Ensigns F. H. Sherman, C. W. Jungen, and T. G. Dewey, U. S. N.	Hydrographic resurvey along the north shore of Long Island Sound between Goshen Point and Hammonassett Point; also determination of dangerous rock in East River, N. Y.
	9	Topography.....	E. Hergesheimer, assistant	Topographic resurvey of the north shore of Long Island Sound from Bridgeport to Frost Point. (See also No. 24, Section II, and Section III.)
	10	Triangulation.....	Spencer C. McCorkle, assistant ..	Re-establishment of points of the old triangulation and determination of additional points on Long Island between Horton's Point and Old Field Point.
	11	Triangulation	Gershom Bradford, assistant......	Supplementary triangulation between Eaton's Point and Sands Point, north coast of Long Island, and of the opposite shore for resurvey of Long Island Sound.
	12	Triangulation	C. O. Boutelle, assistant..........	Completion of the primary triangulation across the State of New York, for connecting the triangulation of Hudson River and Lake Champlain with that of the Lake Survey. (See also Section I.)
	13	Hydrography.....	Lieut. H. B. Mansfield, U. S. N., assistant; Ensigns W. B. Caperton, J. M. Orchard, C. S. McClain, and Harry Phelps, U. S. N.	Hydrographic resurvey of the approaches to New York. (See also Sections VI and VII.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II—Continued.	No. 14	Hydrography....	Lieut. J. C. Fremont, U. S. N., assistant; Ensigns A. F. Fechteler, F. W. Kellogg, and F. R. Brainard, U. S. N.	Observations of currents at stations off New York entrance. (See Section VI.)
	15	Tidal observations	F. W. Shepheard..................	Continuation of series of tidal observations with self-registering tide-gauge at Sandy Hook, N. J.
	16	Geodetic..........	Prof. E. A. Bowser, acting assistant.	Triangulation of the northern part of the State of New Jersey continued, and reconnaissance begun for the extension of the triangulation in the southern part.
	17	Geodetic..........	Mansfield Merriman, acting assistant.	Continuation of the triangulation and reconnaissance of the State of Pennsylvania.
	18	Special survey....	C. H. Sinclair, subassistant; C. H. Van Orden, subassistant.	Survey of the boundary line between the States of Pennsylvania and West Virginia. (See also Section III.)
	19	Topography	C. M. Bache, assistant; W. B. Mapes.	Topographic survey of the New Jersey coast from Cape May Court-House northward.
	20	Physical hydrography.	Henry Mitchell, assistant; Henry L. Marindin, assistant.	Physical hydrography of Delaware River and Bay and location of Port Warden lines in the harbor of Philadelphia.
	21	Topography	R. M. Bache, assistant.............	Topographic resurvey of the New Jersey shore of Delaware Bay continued.
	22	Topography	C. T. Iardella, assistant	Continuation of the topographic resurvey of the western shore of Delaware Bay.
	23	Hydrography.....	Lieut. C. McR. Winslow, U. S. N., assistant; Ensigns William Truxtun, John S. Watters, and Louis S. Van Duzer, U. S. N.	Hydrographic resurvey of Delaware Bay from Mahon's River to Mispillion Creek light.
	24	Topography	E. Hergesheimer, assistant	Topographic resurvey in the vicinity of Cape Henlopen. (See also No. 9, Section II, and Section III.)
	25	Hydrography.....	Lieut. G. C. Hanus, U. S. N., assistant; Lieut. W. G. Cutler, U. S. N.; Ensigns E. F. Leiper and G. R. French, U. S. N.	Hydrographic resurvey of lower Delaware Bay. (See also Sections III, IV, and IX.)
SECTION III.				
Maryland, Virginia, and West Virginia, including bays, seaports, and rivers.	No. 1	Determinations of gravity.	C. S. Peirce, assistant	Determinations of gravity by pendulum experiments and comparison of standards in Europe and in the United States.
	2	Determinations of gravity.	Edwin Smith, assistant...........	Comparative determinations of gravity with the Kater pendulums at Washington.
	3	Magnetic observations.	C. A. Schott, assistant............	Annual determination of the magnetic declination, dip, and intensity at the station on Capitol Hill, Washington.
	4	Telegraphic longitudes.	Francis H. Parsons, subassistant; C. H. Sinclair, subassistant.	Longitude of Covington, Va., by telegraphic exchanges of signals with Washington, D. C. Also observation for latitude of Covington. (See also Sections XIII and XIV.)
	5	Triangulation	C. H. Sinclair, subassistant; J. H. Gray, acting aid.	Occupations of stations for connecting with the triangulation the corner-stones and boundary monuments of the District of Columbia. (See also Section II.)
	6	Topography	John W. Donn, assistant; D. B. Wainwright, assistant.	Continuation of the detailed topographical survey of the District of Columbia.
	7	Topography	E. Hergesheimer, assistant.......	Topographic resurvey of the shores of Cherrystone Inlet, Va. (See also Section II.)
	8	Topography	Eugene Ellicott, assistant....	Topographic surveys in the vicinity of the headwaters of Lynnhaven Bay, Va. (See also Section I.)
	9	Hydrography.....	Lieut. G. C. Hanus, U. S. N., assistant; Ensigns E. F. Leiper and G. R. French, U. S. N.	Hydrographic surveys in the south branch of Elizabeth River, and in North Landing River and Back Bay, Va. (See also Sections II, IV, and IX.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION III—Continued.	No. 10	Geodesic leveling.	John B. Weir, subassistant; John Nelson, acting aid.	Lines of leveling of precision carried from Hagerstown, Md., towards Fortress Monroe, Va. (See also Section VIII.)
	11	Triangulation and magnetic observations.	C. H. Sinclair, subassistant; Isaac Winston, aid.	Connection of the astronomical station at Strasburg, Va., with the triangulation. Magnetic observations at Strasburg. (See also Section II.)
	12	Telegraphic longitudes.	George W. Dean, assistant; Francis H. Parsons, subassistant; Carlisle Terry, jr., aid; J. W. G. Atkins, acting aid.	Determination of the longitude of Charleston, W. Va., by exchanges of telegraphic signals with the station at Louisville, Ky. Also observations for the latitude of the Charleston Station. (See also Sections XIII and XIV.)
	13	Triangulation	A. T. Mosman, assistant; J. F. Pratt, subassistant; W. B. Fairfield, extra observer.	Extension westward of the primary triangulation near the thirty-ninth parallel in West Virginia and Ohio.
	14	Special survey...	C. H. Sinclair, subassistant; C. H. Van Orden, subassistant.	Determination of the boundary lines between the States of Pennsylvania and West Virginia. (See also Section II.)
SECTION IV.				
North Carolina, including coasts, sounds, seaports, and rivers.	No. 1	Hydrography....	Lieut. G. C. Hanus, U. S. N., assistant; Ensigns E. F. Leiper and G. R. French, U. S. N.	Triangulation, topography, and hydrography of North River, N. C. (See also Sections II, III, and IX.)
	2	Hydrography.....	Lieut. J. E. Pillsbury, U. S. N., assistant; Ensigns E. F. Leiper and G. R. French, U. S. N.	Verification of hydrography for the Atlantic Coast Pilot. (See also Sections I and V.)
SECTION V.				
South Carolina and Georgia, including coast, sea-water channels, sounds, harbors, and rivers.	1	Hydrography	Lieut. J. E. Pillsbury, U. S. N., assistant; Ensigns E. F. Leiper and G. R. French, U. S. N.	Verification of hydrography for the Atlantic Coast Pilot. (See also Sections I and IV.)
	2	Reconnaissance....	O. H. Tittman, assistant; W. B. Fairfield, extra observer; J. H. Turner, acting aid.	Reconnaissance for the extension of the primary triangulation in Northern Georgia and Alabama towards Mobile. (See also Sections I and VIII.)
SECTION VI.				
Peninsula of Florida from Saint Mary's River, on the east coast, to and including the Anclote Keys, on the west coast, with the coast approaches, reefs, keys, seaports, and rivers.	No. 1	Topography, hydrography, and magnetic observations.	B. A. Colonna, assistant; Ensign T. G. Dewey, U. S. N.; T. P. Borden and E. L. Taney, aids.	Completion of the survey of the east coast of Florida between Lake Worth and New River. (See also Section XI.)
	2	Current observations.	Lieut. J. C. Fremont, U. S. N., assistant; Ensigns A. F. Fechteler, F. W. Kellogg, and F. R. Brainard, U. S. N.	Observations of currents off the east coast of Florida continued. (See also Section II.)
	3	Triangulation.....	Joseph Hergesheimer, assistant; J. H. Turner, acting aid.	Triangulation of the west coast of Florida in the vicinity of Punta Rasa.
	4	Hydrography....	Lieut. H. B. Mansfield, U. S. N., assistant; Ensigns John M. Orchard, J. P. Parker, John E. Craven, and Harry Phelps, U. S. N.	Hydrographic surveys in the vicinity of the Anclote Keys, in Lemon Bay, and near San Carlos Bay, west coast of Florida. (See also Section II.)
	5	Topography	W. Irving Vinal, subassistant.	Topographic surveys of the Florida coast from the Anclote Keys southward. (See also Section I.)
SECTION VIII.				
Alabama, Mississippi Louisiana, and Arkansas, including Gulf coasts, ports, and rivers.	No. 1	Reconnaissance ..	O. H. Tittmann, assistant; W. B. Fairfield, extra observer; J. H. Turner, acting aid.	Reconnaissance for the extension of the primary triangulation in North Georgia and Alabama towards Mobile. (See also Sections I and V.)
	2	Geodesic leveling.	J. B. Weir, subassistant; John Nelson, aid.	Line of levels of precision carried from the Gulf coast near Mobile towards a point on the transcontinental line of geodesic leveling. (See also Section III.)
	3	Topography and hydrography.	Charles Hosmer, assistant; Ensign Alfred Jeffries, U. S. N.; Carlisle Terry, jr., aid.	Survey of the Gulf coast to the westward of the delta of the Mississippi. (See also Section II.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION VIII—Continued.	No. 4	Triangulation, topography, and hydrography.	F. W. Perkins, assistant; W. C. Hodgkins, subassistant; G. F. Bird and Isaac Winston, aids.	Continuation of the survey of the Gulf coast of Louisiana from Calcasieu Pass eastward. (See also Section XIV.)
SECTION IX.	No. 1	Hydrography.....	Lieut. E. D. F. Heald, U. S. N., assistant; Lieut. G. C. Hanus, U. S. N., assistant.	Hydrographic survey of the coasts of Texas and Louisiana continued between Galveston Entrance and Calcasieu Pass. (See also Sections I, II, III, and IV.)
	2	Reconnaissance...	R. E. Halter, assistant	Reconnaissance for connecting the triangulation in the vicinity of Point Isabel and the mouth of the Rio Grande with Brownsville, Tex.
SECTION X.				
California, including the coast, bays, harbors, and rivers.	No. 1	Triangulation and topography.	A. F. Rodgers, assistant	Survey of the coast of California between San Diego and Newport.
	2	Magnetic observations.	Marcus Baker, acting assistant; Carlisle Terry, jr., aid; P. A. Welker, aid.	Continuation of the series of observations at the magnetic self-registering record station at Los Angeles, Cal.
	3	Triangulation	James S. Lawson, assistant; P. A. Welker, aid.	Continuation of the primary triangulation of the coast of California north of Point Concepcion.
	4	Triangulation and topography.	Stehman Forney, assistant	Survey of the coast of California between Moro Bay and San Simeon Bay.
	5	Hydrography.....	Lieut. E. D. Taussig, U. S. N., assistant; Lieut. F. H. Lefavor, U. S. N.; Ensigns W. L. Burdick and P. B. Bibb, U. S. N.	Hydrographic survey in the vicinity of Point Buchon, Cal., and examination of bar at entrance to San Francisco Bay. (See also No. 9 of this section.)
	6	Triangulation.....	George Davidson, assistant; James S. Lawson, assistant; E. F. Dickins, assistant; P. A. Welker, aid.	Connection of the main triangulation north of Point Concepcion with the transcontinental triangulation near the thirty-ninth parallel.
	7	Tidal observations.	E. Gray	Tidal observations with self-registering tide-gauge continued at Saucelito, near San Francisco Bay entrance.
	8	Determinations of gravity.	R. A. Marr, acting assistant; A. D. Schindler, acting aid; C. B. Hill.	Determinations of the force of gravity at San Francisco in connection with similar observations in Alaska.
	9	Hydrography.....	Lieut. E. D. Taussig, U. S. N., assistant; Lieuts. J. B. Milton and E. P. Elliott, U. S. N.; Ensign P. B. Bibb, U. S. N.	Hydrographic survey of the California coast between Salmon Point and Brushy Point. (See also No. 5 of this section)
SECTION XI.				
Oregon, and Washington Territory, including coast, interior bays, ports, nd rivers.	No. 1	Triangulation, topography, and hydrography.	Louis A. Sengteller, assistant	Survey of Siuslaw River entrance, and continuation of the triangulation and topography of Umpquah River, Oreg.
	2	Triangulation, topography, and hydrography.	Cleveland Rockwell, assistant	Survey of Nestucca Bay and River, Oreg., and continuation of the triangulation and topography of the Willamette River and of the topography of the Columbia River.
	3	Hydrography.....	Lieut. T. Dix Bolles, U. S. N., assistant; Ensign J. N. Jordan, U. S. N., assistant; Ensign J. L. Purcell, U. S. N.	Hydrographic surveys of Gray's Harbor and in the vicinity of Seabeck, W. T.
	4	Triangulation and topography.	J. J. Gilbert, assistant	Continuation of the topography of Hood's Canal, W. T.
	5	Triangulation and topography.	J. F. Pratt, subassistant..........	Continuation of the triangulation and topography of Possession Sound, W. T. (See also Section XIII.)
	6	Triangulation and topography.	B. A. Colonna, assistant; T. P. Borden, aid.	Triangulation and topography of the Strait of Fuca, W. T. (See also Section VI.)
	7	Hydrography.....	Lieut. Commander A. S. Snow, U. S. N., assistant; Lieut. G. Blocklinger, U. S. N.; Ensigns, W. V. Bronaugh, F. M. Bostwick, and W. P. White, U. S. N.	Hydrographic survey of the Strait of Fuca, W. T. (See also Section I.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION XII.				
Alaska, including the coast and the Aleutian Islands.	No. 1	Hydrographic reconnaissance.	Lieutenant-Commander H. E. Nichols, U. S. N., assistant.	Hydrographic reconnaissance of the bays and harbors of Southeastern Alaska continued.
	2	Tidal observations	W. J. Fisher	Tidal observations with self-registering tide-gauge continued at Saint Paul, Kadiak Island, Alaska
	3	Force of gravity and magnetic observations.	R. A. Marr, acting assistant; A. D. Schindler, acting aid.	Expedition to Point Barrow, Alaska, for the purpose of determining gravity and the magnetic elements. (See also Section X.)
SECTION XIII.				
Kentucky and Tennessee..	No. 1	Telegraphic longitudes.	George W. Dean, assistant; Francis H. Parsons, subassistant; Carl Schenck, acting assistant; Carlisle Terry, jr., aid; J. W. G. Atkins, acting aid.	Occupation of the longitude station at Louisville, Ky., for the determination of the longitudes of stations in Tennessee, Kentucky, West Virginia, Indiana, and Illinois by exchanges of telegraphic signals. Observations for latitude at stations not before determined. (See also Sections III and XIV.)
	2	Geodetic..........	J. F. Pratt, subassistant..........	Extension of reconnaissance and triangulation in the State of Kentucky. (See also Sections III and XI.)
	3	Geodetic..........	Prof. A. H. Buchanan, acting assistant.	Continuation of the triangulation of the State of Tennessee.
SECTION XIV.				
Ohio, Indiana, Illinois, Michigan, and Wisconsin.	No. 1	Geodetic.........	Prof. R. S. Devol, acting assistant.	Occupation of stations for the extension of the triangulation of the State of Ohio.
	2	Geodetic.........	Prof. J. L. Campbell, acting assistant.	Reconnaissance for the continuation of the triangulation of the State of Indiana.
	3	Triangulation ...	George A. Fairfield, assistant; F. W. Perkins, assistant; Isaac Winston, aid.	Continuation to the eastward of the primary triangulation in Illinois near the thirty-ninth parallel.
	4	Telegraphic longitudes.	George W. Dean, assistant; Francis H. Parsons, subassistant; Carlisle Terry, jr., aid; J. W. G. Atkins, acting aid.	Determination of the longitudes of Logansport, Ind., and of Chicago, Ill., by exchanges of telegraphic signals with Louisville, Ky. Observations for latitude at Logansport and Chicago. (See also Sections III and XIII.)
	5	Geodetic..........	Prof. J. E. Davies, acting assistant.	Stations occupied in continuation of the triangulation of the State of Wisconsin.
SECTION XV.				
Missouri, Kansas, Iowa, Nebraska, Minnesota, and Dakota.	No. 1	Triangulation.....	F. D. Granger, assistant; J. E. McGrath, aid; A. P. Barnard, acting aid.	Occupation of stations for continuing to the westward the primary triangulation in Missouri and Kansas near the thirty ninth parallel.
SECTION XVI.				
Nevada, Utah, Colorado, Arizona, and New Mexico.	No. 1	Triangulation	William Eimbeck, assistant; George F. Bird, aid.	Occupation of stations in Nebraska and reconnaissance in Utah for the extension eastward of the primary triangulation near the thirty-ninth parallel.
SPECIAL OPERATIONS.		Charge of construction of the Coast and Geodetic Survey steamer Carlile P. Patterson.	Lieut. Commander C. M. Chester, U. S. N., Hydrographic Inspector; Lieut. Richardson Clover, U. S. N., assistant.	Brooklyn, N. Y.
		Charge of the Coast and Geodetic Survey Exhibit at the Southern Exposition.	H. W. Blair, assistant; John Clark, mechanician.	Louisville Ky.

APPENDIX No. 1—Continued.

Section.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SPECIAL OPERATIONS—Continued.		Comparisons of standards of weight and measure, and investigations relating to determinations of gravity.	Charles S. Peirce, assistant.......	London, Paris, Brussels, Geneva, and other stations in Europe.
		Attendance of a delegate on the part of the Coast and Geodetic Survey at the International Geodesic Conference.	Richard D. Cutts, assistant in charge of office.	Rome. Italy.
		Transportation for comparison of important standards of weight and measure.	Prof. Thomas Craig, Johns Hopkins University.	From British Standards Office, London, to International Bureau of Weights and Measures, Paris.
		Tidal observations.	Superintendent of Hawaiian Government Survey.	Honolulu, Sandwich Islands.

APPENDIX No. 2.

Statistics of field and office work of the Coast and Geodetic Survey for the year ending June 30, 1884.

	Total to June 30, 1883.	Total during fiscal year.	Total to June 30, 1884.
RECONNAISSANCE.			
Area in square statute miles	286 750	44 350	331 100
Parties, number of	....	4	....
BASE-LINES.			
Primary, number of	14	0	14
Primary, length of, in statute miles	90	0	90
Secondary, number of	127	2	129
Secondary, lines and line measures, length, in statute miles	426	16	442
TRIANGULATION.			
Area in square statute miles	190 697	2 723	193 420
Stations occupied for horizontal measures, number of	10 522	176	10 698
Geographical positions determined, number of	20 058	420	20 478
Stations occupied for vertical measures, number of	656	26	682
Elevations determined trignometrically, number of	1 719	64	1 783
Elevations determined by spirit-leveling, number of bench-marks	2 097	592	2 689
Lines of spirit-leveling, length of, in statute miles	2 486	447	2 933
Triangulation and leveling parties, number of	....	28	....
ASTRONOMICAL WORK.			
Azimuth stations, number of	183	4	187
Latitude stations, number of	296	16	312
Longitude stations, telegraphic, number of	115	9	124
Longitude stations, chronometric or lunar, number of	110	0	110
Astronomical parties, number of	....	8	....
MAGNETIC WORK.			
Stations occupied, number of	664	11	675
Permanent magnetic stations, number of	....	2	....
Magnetic parties, number of	....	7	....
TOPOGRAPHY.			
Area surveyed, in square statute miles	28 683	451	29 134
Length of general coast, in statute miles	6 489	239	6 728
Length of shore-line, in statute miles, including rivers, creeks, and ponds	82 578	1 932	84 510
Length of roads in statute miles	41 936	487	42 423
Topographical parties, number of	....	25	....
HYDROGRAPHY.			
Parties, number of	....	24	....
Number of miles (geographical) run while sounding	356 569	12 846	369 415
Area sounded, in square geographical miles	90 704	4 631	95 335
Miles run, additional to outside or deep-sea sounding	74 748	....	74 748
Number of soundings	16 203 402	481 008	16 684 410
Deep-sea soundings	12 936	....	12 936
Deep-sea temperature observations	11 801	....	11 801

APPENDIX No. 2—Continued.

	Total to June 30, 1883.	Total during fiscal year.	Total to June 30, 1884.
HYDROGRAPHY—Continued.			
Tidal stations, permanent, number of	259	4	263
Tidal stations, temporary, number of	1 910	58	1 968
Tidal parties, number of		27	
Current stations, number of	587	28	615
Current parties, number of		1	
Specimens of bottom, number of	12 092	246	12 338
RECORDS.			
Triangulation, originals, number of volumes	4 010	295	4 305
Astronomical observations, originals, number of volumes	1 651	87	1 738
Magnetic observations, originals, number of volumes	536	27	563
Duplicates of above, number of volumes	4 200	347	4 547
Computations, number of volumes	3 579	240	3 819
Hydrographic soundings and angles, originals, number of volumes	8 707	313	9 020
Hydrographic soundings and angles, duplicates, number of volumes	1 699	196	1 895
Tidal and current observations, originals, number of volumes	3 462	130	3 592
Tidal and current observations, duplicates, number of volumes	2 262	84	2 346
Sheets from self-registering tide-gauges, number of	2 924	75	2 999
Tidal reductions, number of volumes	1 880	36	1 916
MAPS AND CHARTS.			
Topographic maps, originals	1 642	27	1 669
Hydrographic charts, originals	1 721	38	1 759
Reductions from original sheets	927	18	945
Total number of manuscript maps and charts	2 688	18	2 706
Number of sketches made in field and office	3 206	40	3 246
ENGRAVING AND PRINTING.			
Engraved plates of finished charts, number of	267	7	274
Engraved plates of preliminary charts, sketches, and diagrams for the Coast and Geodetic Survey reports, number of	639	11	650
Electrotype plates made	1 663	95	1 758
Finished charts published	391	17	408
Engraved plates of Coast Pilot charts	62	15	77
Engraved plates of Coast Pilot views	78	10	88
Printed sheets of maps and charts distributed	533 205	16 220	549 425
Printed sheets of maps and charts deposited with sale agents	212 062	17 418	229 480

APPENDIX No. 3.

Information furnished to Departments of the Government in reply to official requests, and to individuals upon application,* during the fiscal year ending June 30, 1884.

Date.		Name.	Data furnished.
1883.			
July	5	R. Templeman, Fort McHenry, Md	Magnetic declination at Baltimore.
	5	Prof. T. C. Mendenhall, Ohio State University	Magnetic intensity at Columbus, Ohio.
	6	Post-Office Department	Distance in statute miles between Bayou Sara and Natchez, Miss. (103 miles).
	7	O. O. Knabenshue, Columbus, Ohio	Length of parallel of 30 degrees.
	9	R. A. Adair, Parkersburg, W. Va	Height of bench-mark at custom-house, Parkersburg.
	9	J. W. Powell, Director United States Geological Survey	Geographical positions, azimuths, and distances of six trigonometrical points in West Virginia and Virginia, with descriptions of stations.
	9	Simon Stevens, No. 61 Broadway, New York	Hydrographic survey of the vicinity of High Island, near Hart and City Islands, Long Island Sound, 1882.
	10	Major C. W. Raymond, Corps of Engineers, U. S. A	Geographical position of triangulation points, eastern extremity Cape Ann, Mass.
	10	W. L. Lancaster, Blacksburg, Va	Tables of magnetic declination in Virginia.
	10	J. J. Kennedy, Philadelphia, Pa., 411 and 413 Walnut street.	About bench-mark on light-house at Cape May, N. J.
	10	Major Charles W. Raymond, Corps of Engineers, U. S. A.	Description of United States Coast Survey bench-mark at Rockport, Mass.
	11	Col. Q. A. Gillmore, Corps of Engineers, U. S. A	Geographical position and descriptions of stations Savannah River below Bird Island (third communication).
	11	E. N. Jones, M. D., Taunton, Mass	The height above sea-level of a point in Taunton, Mass.
	14	Robert Milikin, county surveyor, Emporia, Kans	Magnetic declination at Emporia, Kans.
	16	Thomas P. Morgan, Washington, D. C	The tides at Washington, a copy of Tide Tables for 1883 with notes.
	16	J. Francis Le Baron, United States Engineer Office, Jacksonville, Fla.	Tides and descriptions of bench-marks at New Berlin, Saint John's River, Fla.
	19	J. H. Morrison, 24 Park Place, N. Y.	Distance on the Mississippi River between New Orleans and Cairo.
	21	Major Charles W. Raymond, Corps of Engineers, U. S. A.	Tracing of hydrographic survey of Sandy Bay, Rockland Harbor, Mass., and a projection, scale 1-10000, with shore-line and points.
	21	D. Porter, census office, Hartford, Conn	Difference in height between mean low water at Albany and mean sea level in New York Harbor.
	23	Major C. J. Allen, Corps of Engineers, U. S. A	Position and description of station "Balch," Portland, Oreg.
	23	Major J. W. Reed, Chincoteague, Accomac County, Va	Hydrographic survey of Oyster Bay, Chincoteague, Va.
	27	Samuel H. McElroy, C. E., Brooklyn, N. Y	Hydrography off Coney Island, N. Y., 1881.
	28	General Land Office, Interior Department	Two hundred and eighty-eight geographical positions in the State of Oregon or near its boundary.
	30	Simon Stevens, New York	Survey of High Island and vicinity; western end Long Island Sound, enlarged to 1-2000.
Aug.	1	C. C. Perkins, city surveyor office, Boston, Mass	Descriptions of stations near Nahant, Mass.
	2	Past Assistant Engineer N. B. Clark, U. S. N.	Position and approximate height of triangulation station "Clark," near Philadelphia, Pa.
	2	J. Herbert Shedd, C. E., chairman Rhode Island Harbor Commission.	Surveys of the western shore of Narragansett Bay, R. I., 1865–'69, from Rocky Point to Quonset Point, including Greenwich.
	6	G. W. Torrence, Philadelphia Bible Society, NW. cor. 7th and Walnut streets.	Information as to Government pier, Chester, Pa.

* Tracings from topographic or hydrographic sheets, transcripts of unpublished results of the work, and other data, when furnished for private use, are supplied upon payment of the cost of preparation in the office.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1883.			
Aug.	7	G. Randolph, West Chester, Pa	Magnetic declination at Millboro, Bath County, Va., and secular change since 1795.
	8	E. L. Brown, civil engineer	Geographical positions of four stations vicinity of Martha's Vineyard, Mass., and descriptions of stations.
	9	J. P. Bogart, engineer Shell-fishery Commission, New Haven, Conn.	Information respecting boundary line between New York and Connecticut.
	11	J. M. Trowbridge, Summitsville, Rio Grande, Colo	Method for marking out a true meridian.
	11	Lieut. Col. G. Weitzel, Corps of Engineers U. S. A.	A self-registering tide-gauge and supplies for it, furnished to him for use at Fort Mifflin.
	13	Boundary Commission, Pennsylvania and Ohio	Star lists for determination of two latitude stations.
	14	Lieut. E. K. Moore, United States Navy	Telegraphic longitude of Springfield, Ill., and of Chicago, Ill.
	15	M. Duckett, Bladensburg	Magnetic declination at Baltimore for 1686 and 1883.
	15	Bureau of Statistics, Washington, D. C	Distances between Liverpool and San Francisco and Liverpool and New York.
	16	W. Williams, C. E., and city surveyor Hackensack, N. J.	Secular variation of magnetic declination at New York City.
	20	W. C. Kerr, United States Geological Survey	Distances and angles to four subordinate trigonometrical points in North Carolina.
	22	Mississippi River Commission	Topographical survey of shores of Mississippi River, Donaldsonville, La., and vicinity, 1880.
	24	Major L. L. Livingston, U. S. A., Artillery School, Fort Monroe.	Bench-mark of Fort Monroe and loan of self-registering tide-gauge for use there.
	29	G. Randolph, West Chester, Pa	Information about secular variation of the magnetic declination since 1795.
	29	J. J. Bleich, United States Internal-Revenue Service, Paducah, Ky.	Longitude of Paducah and Louisville, Ky., and Washington, D. C.
	30	Cauthorn & Boyle, Attorneys-at-Law, Vincennes, Ind	Geographical position of Vincennes, Ind., and description of astronomical station.
	30	T. H. Edsall, New York	Description of Fort Independence Station, on Spuyten Duyvil Creek Neck.
	30	Mr. L. B. Russell, Refugio, Tex	Tracing of upper part of San Antonio Bay, Tex.
Sept.	1	E. R. Von Nardroff, Brooklyn, N. Y	Magnetic declination in direction and intensity observed by the Coast and Geodetic Survey; also secular change in the declination in the United States.
	3	E. Pendleton, Attorney-at-Law, Lexington, Va.	Magnetic declination on line between Bath County and Rockbridge County, Va.
	3	Ex-Senator John B. Gordon, Georgia	Unfinished chart of Aransas and Copano Bays, Tex.
	7	J. B. Hoeing, Topographer Geological Survey, Kentucky	Longitude of five stations in Kentucky and Tennessee, with descriptions of stations.
	7	Col. Henry Stone, South Boston, Mass	Topographical survey of the approaches to Nashville, Tenn., 1864.
	10	W. K. Duason, La Grange, Ky	Magnetic declination at Louisville and La Grange, Ky.
	12	H. F. Bothfeld, United States Civil Engineer, Boston, Mass.	Bench-marks at Boston and tides there in August, 1866.
	14	Health office of the District of Columbia	Times of high water at Long Bridge, Washington, D. C.
	14	Mr. Carrington, Washington, D. C	Times of high water in the Patuxent, September 15.
	15	J. K. Payne, Knoxville, Tenn	Information about magnetic declination and defects of instruments, with compass attachment.
	18	T. C. Dupont, Central Coal and Iron Company, Louisville, Ky.	Magnetic declination near Central City, Ky.
	19	Lieutenant E. K. Moore, United States Navy, United States Naval Observatory.	Longitude of Syracuse, N. Y.
	19	Civil Engineer R. E. Peary, United States Navy	Combined hydrographic surveys of Coasters Island Harbor, R. I.
	20	E. L. Woodside, South Holliday street, Baltimore, Md	Information about bench-marks and tides in Gunpowder River, Md.
	21	J. Herbert Shedd, Chairman Rhode Island Harbor Commission.	Traced copy of the plane-table shore-line of Narragansett Bay, including the contours of bottom to limits of 6, 12, and 18 feet, of the Western Passage from Quonset Point to the "Bonnet," scale 1-10000.
	21	.....do	Same, from North Point to Dyer's Island including Bristol Harbor, scale 1-10000.
	21	......do	Same, from Bristol Ferry to Taunton Ferry, including Mount Hope Bay, scale 1-10000.
	29	Simon Stevens, New York	Combined chart of Riker's Island and vicinity, East River, N. Y., scale 1-5000.
	29	Appalachian Mountain Club, Boston, J. R. Edwards, topographer.	Geographical positions and bearings of points in New Hampshire, Vermont, New York, and Canada, adjacent to boundary.
Oct.	1	Cecil C. Higgins, 48 Wall street, New York	Photolithographic chart of Somes Sound, Mount Desert Island, Me., scale 1-10000.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1883.			
Oct.	8	Prof. George H. Cook, State Geologist, New Jersey	Topographic survey, coast of New Jersey, Tom's River to Metiticonk River, 1875, 1-10000.
	10	Ed. Channing, Harvard University, Cambridge, Mass	The time of high water at Plymouth, Mass., December 21, 1620, when the Pilgrims landed.
	12	J. P. Bogart, Engineer Shell Fishery Commission, Connecticut.	Hydrographic and topographic map of north shore of Long Island Sound, vicinity Manursing Island, 1836.
	13	Lieutenant Smith S. Leach, Secretary Mississippi River Commission, Saint Louis.	Six blank tide-rolls for self-registerng tide-gauge at Biloxi, Miss.
	17	R. A. Russell, Cobton, N. C	Secular variation of magnetic declination at New Berne, N. C.
	17	F. W. Hastings, C. E., Saint Louis, Mich	Geographical position of Saint Louis, Mich.
	19	Cecil C. Higgins, 48 Wall street, New York	Topographic survey, west side Somes Sound, south of Somesville, Mount Desert Island, Me.
	23	Struthers, Scroos & Co., New York	Prominent geographical positions in the United States, determined astronomically and geodetically by the Coast and Geodetic Survey.
	26	Lieutenant F. V. Abbot, Corps of Engineers, United States Army.	Geodetic data and descriptions of stations of the triangulation of Pocomoke Sound and Chincoteague Bay, vicinity of boundary of Maryland and Virginia.
	31	......do	Geodetic data and descriptions of stations of the triangulation, vicinity of Smith's Island, Chesapeake Bay.
	31	E. W. Muenscher, Chief Engineer K., St. E. & S. R. R.	Elevation and description of bench-marks at Salem and Odin, Ill.
	31	Prof. E. A. Fuertes, Cornell University	Correction to thermometers of base bars.
	31	Cecil C. Higgins, 48 Wall street, New York	Compiled hydrography of surveys of Hell Gate and vicinity, 1856, 1-5000.
Nov.	5	Henry Mitchell, Boston Mass	Topographic survey of Nantucket, 1846.
	9	Robert V. Roosevelt, New York	Coast chart No. 54, with additions by hand, of the inside passage between Stono and Wadmelaw Rivers, S. C.
	13	Prof. R. W. McFarland, Ohio State University	Astronomical position of Coast and Geodetic Survey stations at Columbus, Ohio.
	15	United States Signal Office	Longitude of Wheeling, W. Va.
	15	Chief of Engineers, United States Army	Autographic maps of Wickford Harbor and Greenwich Bay, Narragansett Bay, and traced copy of topographic work between the above.
	17	Capt. J. W. MacMurray, United States Army	Topographic survey of Cape Disappointment, Washington Territory, 1869-'73.
	17	C. G. Force, M. A. S. C. E., Cleveland, Ohio	Difference of longitude between Washington. D. C., and Cleveland, Ohio.
	17	A. M. Ford, Atlantic City, N. J	Information relating to some parts of the tide tables for the Atlantic Coast for 1884.
	21	General W. B. Hazen, Chief Signal Officer, United States Army.	Copy of sketch of summit of Mount Washington, 1877, scale 1-480.
	22	Lieutenant-Commander T. A. Lyons, United States Navy	Magnetic dip at San Francisco, Cal.
	22	Light-House Board	List of geographical positions of lights corrected to date for new edition for 1884.
	26	Mr. Trautwine, Philadelphia, Pa	Magnetic declination at Philadelphia, Pa.
	26	George Fisher, Surveyor of Customs, Cairo, Ill	Geographical position of Coast and Geodetic Survey astronomical station, Cairo, Ill.
	26	A. S. Pennington, Paterson, N. J	About the tides in Raritan and Newark Bays and connecting waters.
	27	J. W. Powell, Director United States Geological Survey	Sketch of the North Mountain Range from Cape Mount, Va., to Casey's Knob, Pa., scale 1-40000.
	30	Lavalette Wilson, A. M., C. E., and Surveyor, Haverstraw, N. Y.	Togopraphic survey of west shore of Hudson River from Wadlerg landing to Rockland Lake landing, scale 1-10000.
	30	W. H. Ogden, Parkersburg, W. Va	Longitude of Parkersburg, W. Va.
Dec.	11	S. L. Smedley, Philadelphia	Six geographical positions on the Delaware River.
	11	United States Geological Survey	The angles observed at station, Hog Back, S. C.
	11	D. E. McComb, Assistant District Engineer, Washington, D. C.	Description of bench-mark at the Washington Navy-Yard, D. C.
	12	Mr. Volney D. Moody, President First National Bank, Oakland, Cal.	Hydrographic survey coast of California, between Piscadore Point and Point Carmel, including Carmel Bay, 1883, scale 1-10000.
	17	Dr. W. C. Hatch, West's Mills, Me	Height of Bannock Hill and Mount Blue, Me.
	17	Prof. S. Newcomb, United States Navy	Length of line, Fort Myer to Washington Monument.
	17	Prof. E. A. Fuertes, Cornell University, Ithaca, N. Y	Photographic views of Coast Survey's primary station on Sugar Loaf Mountain, Md.
	17	Philadelphia Maritime Exchange	Hydrographic survey vicinity Cape Henlopen, 1883.
	19	S. G. Gano, engineer, Flemington, N. J	Magnetic declination in the United States.
	21	Professor Sadebeck	Geodetic literature in United States 1880, '81, '82

APPENDIX No. 3—Continued.

Date.	Name.	Data furnished.
1883.		
Dec. 22	J. S. Boulton, Staff Commander Royal Navy, Ottawa, Canada.	Magnetic information relating to Georgian Bay.
22	Cole Manufacturing Company, Lake Village, N. H	Magnetic declination at Lake Village, between 1845 and 1885.
27	J. Herbert Shedd, C. E., Providence, R. I	Description of bench-mark for tides, Bristol, R. I.
28	Prof. S. Newcomb, U. S. N., Washington, D. C	Relating to tides at Sharp's Island, Chesapeake Bay.
31	Prof. E. A. Bowser, New Brunswick, N. J	Geodetic data of stations Applepie Hill and Ridgeway, N. J.
1884.		
Jan. 2	J. Herbert Shedd, C. E., Providence, R. I	Relating to tidal bench-mark at Bristol, R. I.
5	Samuel H. Lyman, Clerk United States District Court, Southern District New York.	Water fronts of New York, Brooklyn, and Jersey City, scale 1-10000.
7	George R. Howell, New York State Library, Albany, N. Y.	Height of three trigonometrical stations on Long Island, N. Y.
7	A. M. Ford, Salem, N. J	Relating to the effects of the Java earthquake on the tidal curve at Saucelito, Cal.
8	Joseph Nimmo, jr., Chief of Bureau of Statistics, Treasury Department.	Data in regard to the length of the boundary line between the United States and Mexico.
10	Charles E. Monroe, Washington, D. C	The time of high water at Pass à l'Outre, on 16th May, 1861.
11	J. W. Powell, Director United States Geological Survey..	156 geographical positions District of Columbia and vicinity, in Maryland and Virginia.
14	G. W. Tate, surveyor, Mebanesville, N. C	Secular variation of the magnetic declination vicinity Raleigh, N. C.
15	James H. Britton, State Engineer of Texas	Proof of Coast Chart 109, Aransas Pass, Aransas and Copano Bays, Tex.
16	Lieut.-Col. George H. Elliott, Corps of Engineers, U. S. A..	Shore line of Nantucket Harbor, Mass., 1846 and 1865.
17	J. H. Morrison, New York	Distance along the Hudson from New York to Albany.
18	G. P. Strum, General Land Office	Geographical positions determined by the Coast and Geodetic Survey in Nebraska and Colorado.
23	J. Hotchkiss, Staunton, Va	Telegraphic longitude of Covington, Va.
24	J. W. Powell, Director United States Geological Survey...	Geographical positions of stations Ivy, and Paint Creek, W. Va.
26	Judge Charles J. McCurdy, Old Lyme, Conn	Topographic survey of the eastern shore of the Connecticut River, from Lyme southward.
31	A. L. Williams, Aiken, S. C	Magnetic declination and secular change at Aiken, S. C.
31	Charles C. Hutchinson, 126 Commercial street, Boston....	About instruments for observing tidal currents.
31	George A. Stockwell, Providence, R. I	Explanation of some matters in the tide tables.
Feb. 1	Charles H. Campbell, New York	Relating to tides in Saint Helena Sound, S. C.
4	Charles A. Ashburner, Geologist in Charge Second Geological Survey of Pennsylvania.	Geographical positions of Harrisburg, Pa.
7	Commissioner General Land Office	Topographic survey south shore Long Island eastward from Far Rockaway to longitude 73° 41′, 1878–1879, scale 1-10000.
7	......do	Tracing showing comparison of shore line south shore of Long Island eastward from Far Rockaway surveys, 1835–'59–'60.
7	Prof. Raphael Pumpelly, Newport, R. I	Topographic survey of the island of Rhode Island in two sections, scale 1-10000.
7	..... do	Same, showing contour lines only, 1-10000.
9	J. D. Steele, Elmira, N. Y	Annual change of dip and declination at New York and Washington, and dip at New York.
9	General Q. A. Gillmore, United States Army, New York ..	Description of bench-mark at Fort Monroe.
9	Lieut. Col. Geo. H. Elliot, Corps Engineers, United States Army.	Hydrographic survey harbor Nantucket, 1872, scale 1-20000.
12	G. J. Brown & J. H. Briggs, Robbinston, Me	Change in the magnetic declination coast of Maine between 1790 and 1884.
18	George A. Stockwell, Providence, R. I	Relation of tides at Boston and Newport.
25	Prof. G. H. Cook, State Geologist, New Jersey	Description of boundary monument on western end of boundary line New York and New Jersey.
25	Roy Stone, 2 West Thirty-ninth street, New York	Relating to the plane of mean low water at Sandy Hook tide-gauge.
29	J. W. Powell, Director United States Geological Survey..	Geographical positions of Charleston, W. Va., and Louisa, Ky.
Mar. 3	Captain Charles F. Powell, Corps of Engineers, U. S. A., Portland, Oreg.	Relating to bench-marks and plane of reference at Astoria, Oreg.
4	C. A. Whitmore, Grand Rapids, Mich	Information respecting dates in connection with early history of coast survey.
5	Hon. Melvin C. George, Oregon	Copies of surveys of Siuslau River entrance, and of Nistucca Bay and River, Oreg., 1883, scale 1-10000.
5	W. S. Warner, Palma Sola, Fla	Survey of Little Sarasota Pass to Casey's Pass, west coast of Florida, 1883.
5	George W. Atherton, President Pennsylvania State College.	Copies of triangulation sketches, showing progress to 1884.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1884.			
Mar.	7	E. Deville, Technical branch, Department of the Interior.	Determination of constants for a magnetic dip circle.
	14	Simon Stevens, 61 Broadway, New York City	West shore Long Island Sound, Throggs Neck to David's Island, 1837-'81-'82.
	19	Prof. C. Bancroft, Hiram College, Ohio	Information on works on geodesy.
	19	W. H. Hall, State Engineer, California	List of geographical positions corrected to date.
	21	Hon. Wm. Freeman, Cherryfield, Me	Hydrography off Joe Dyer's Point, Pigeon Hill, Me.
	26	Philadelphia and Reading Railroad Company	West shore of Arthur Kill or Staten Island Sound, Elizabethport to Tuft's Point.
	28	William Senter & Co., Portland, Me	Predicted tides for Portland, Me., and Boston, Mass., for January, February, and March, 1885.
	30	A. Ramsay, Secretary of the Krakatoa Committee Royal Society, London.	Relating to records of earthquake waves on the tide-gauges of the United States Coast and Geodetic Survey.
Apr.	1	George H. Williams, Johns Hopkins University	Topographic survey of east shore of Hudson River from Croton to Peekskill, scale 1-10000, and of west shore vicinity of Stony Point, 1881, scale 1-10000.
	2	Milton Andros, Engineer, San Francisco, Cal	Predicted tide curves for 3d, 4th, and 5th September, 1883, for Clatsop Spit, mouth Columbia River, Oreg.
	3	J. F. Rodgers, Albany, N. Y	Results of spirit leveling on Hudson River.
	5	A. L. Webster, Johns Hopkins University, Baltimore, Md.	One hundred and forty-five geographical positions within a radius of 12½ statute miles of Baltimore, Md.
	7	J. W. Powell, Director United States Geological Survey.	Heights of trigonometrical positions in District Columbia, Maryland, and Virginia.
	8	M. Gillet & Co., Baltimore	Difference of time between Hagerstown, Md., and the 75th meridian.
	10	W. Libbey, jr., Princeton, N. J	Formulæ for computing the length of a degree of the meridian and the parallel; also for computing length of the quadrant; and information as to tides.
	10	W. E. Rosser, Prairie Grove, Ark	Position of Fayetteville, Washington County, Ark.
	10	J. K. Rhees, Professor of Geodesy, Columbia College, New York.	Geodetic data, descriptions of stations, and latitudes, longitudes, azimuths and distances of a number of trigonometrical points in vicinity of New York City.
	10	Jas. Gardiner, Director New York State Survey, Albany, N. Y.	Geodetic results of the Coast and Geodetic Survey triangulation between Lakes Champlain and Ontario.
	17	Peter Cantine, Attorney at Law, New York	Hydrographic survey of Hudson River above and below Esopus Light-House, 1861, scale 1-10000.
	16	P. B. Wood, Peshtigo, Wis	Magnetic declination, dip and intensity at Madison, Wis.
	19	J. Eaton, Commissioner of Education	Reply to the hydrodynamic question connected with Mississippi River.
	19	Prof. George H. Cook, State Geologist of New Jersey	Topographic surveys North and South Srewsbury River, 1864-'65.
	19	......do	Topographic surveys Long Branch and vicinity, 1866.
	19	......do	Topographic surveys Deal and Squam beach, 1867.
	19	......do	Topographic surveys Manasquan and Metiticonk Rivers, 1868.
	19	......do	Topographic surveys New England Creek to Goshen Creek, 1883.
	19	......do	Topographic surveys Cold Spring Inlet to Hereford Inlet, 1880.
	19	......do	Topographic surveys Hereford Inlet to Leaming's Sound, 1881.
	19	......do	Topographic surveys vicinity of Leaming's Sound, 1883.
	22	James Gardiner, Director New York Survey, Albany, N. Y.	Abstracts of horizontal directions obsereved and adjusted, of triangulation between Lakes Champlain and Ontario.
	25	Prof. J. L. Howe, Central University, Richmond, Ky	Geographical position of Richmond, Ky.
	26	W. J. Johnston, Johnson City, Tenn	Length of 1′ of arc in meridian and in different parallels, latitude 36° to latitude 36½°.
	29	E. G. Dyke, Crescent City, Fla	Advice as to magnetic declination at Crescent City, Fla.
May	2	Thomas J. Long, Assistant to Engineer-in-Chief, Department of Docks, New York City.	Bench-marks around New York and their relation to mean level of the water—Governor's Island, Brooklyn Navy-Yard, Jersey City, Astoria, Pot Cove, New Yokk, 41st, 86th, and 90th streets.
	3	George W. Emerson, Hoginam, Wash. T	Hydrographic survey, Gray's Harbor, Wash. T., 1883.
	3	W. S. Walker, Saint Augustine, Fla	Topography of coast of Florida, from Matanzas Inlet to Smith's Creek.
	5	N. Spofford, Surveyor and Civil Engineer, Haverhill, Mass.	Information as to tidal waves in connection with river slopes.
	5	C. A. Locke, Decatur, Ga	Information respecting magnetic declination and annual change, at Decatur, Ga.
	7	Charles H. Rockwell, Tarrytown, N. Y	Position of boundary-stone marking the New York and New Jersey boundary, on the right bank of the Hudson.
	7	John Carmichael, C. E., Lexington, Va	Magnetic declination at Lexington in 1785 and 1790.
	8	Captain F. V. Greene, Corps of Engineers, U. S. A., Assistant to Engineer Commissioner, District of Columbia.	Bench-marks and tides in and around Washington, D. C.

APPENDIX No. 3—Continued.

Date.	Name.	Data furnished.
1884.		
May 12	Captain F. V. Greene, Corps of Engineers, U. S. A., Assistant to Engineer Commissioner, District of Columbia.	Height of the Coast and Geodetic bench-mark above the Potomac and the average ocean level.
12	J. F. Le Baron, Deputy County Surveyor, Jacksonville, Fla.	Explanatory note as to magnetic declination at Jacksonville, Fla.
14	J. Schubert, Engineer and Architect, Parkersburg, W. Va.	Height of bench-mark at Parkersburg, W. Va.
14	Prof. G. H. Cook, State Geologist New Jersey, New Brunswick, N. J.	Description of ninety-eight geographical stations in New Jersey south of Raritan Bay.
19	E. P. Austin, computer American Nautical Almanac, Salt Lake City, Utah.	Copy of tidal predictions for Boston for 1885, to be used for an almanac to be published there.
22	J. F. Le Baron, C. E., Jacksonville, Fla	Topographic survey of Jacksonville and vicinity, Fla., 1855-'56.
23	Captain Charles F. Powell, U. S. A., Engineer Thirteenth Light-house District.	Survey of Gray's Harbor, Wash. T.
23	.... do	Reconnaissance Destruction Island, Wash. T.
24	J. P. Bogart, Engineer to Connecticut Shell-Fishery Commission.	Geographical positions and descriptions of stations, vicinity Stonington, Conn.
27	R. H. Goode, City Engineer Office, Norfolk, Va	Information on method of least squares.
27	J. W. Powell, Director United States Geological Survey.	Geographical positions of primary triangulation stations in Northwestern Virginia.
29	W. J. Johnston, Johnson City, Washington County, Tenn.	Change of magnetic declination between 1796 and 1884 at Johnson City, Tenn.
29	Col. Chas. E. Blunt, Corps of Engineers, U. S. A	Hydrographic survey of part of Muscle Ridge Channel, Me., 1863.
June 2	J. D. O'Connell, Treasury Department, Washington, D. C	Magnetic declination near Alamosa and near Cimarron, Colo.
2	Dr. Henry J. Bigelow, Boston	Topographic survey of Tuckernuck Island, Nantucket, 1846.
2	General John Newton, Chief of Engineers United States Army.	Hydrographic survey of East River, showing location of rock off 20th street, New York, May 27, 1884.
5	G. F. Le Baron, Deputy County Surveyor, Jacksonville, Fla.	Magnetic declination at Jacksonville, Fla., in 1833-'49-'80 and '85, with annual change.
12	F. B. French, tidal observer at Biloxi, Miss	Five pamphlets on tides by Mr. Ferrel and one by Mr. Avery.
16	J. W. Powell, Director United States Geological Survey	Positions of five primary stations in Georgia and angles to secondary stations.
19	........do	Geographical positions of Saint Helena, Sulphur Park, and Saucelito, Cal.
19	Lieutenant Smith S. Leach, Corps of Engineers, U. S. A., Secretary Mississippi River Commission, Saint Louis, Mo.	Five blank tide-rolls sent for the gauge at Biloxi, Miss., to F. B. French.
19	Senator John R. McPherson, of New Jersey	Areas of salt marsh and tidal basins of New York Harbor.
20	D. T. Polk, C. E., New Market, Mo	Information respecting magnetic declination instruments.
23	Department of Marine, &c., Ottawa, Canada	Magnetic results from observations by Lieutenant Very, United States Navy, Acting Assistant, Coast and Geodetic Survey, coast of Labrador and trip to Hudson Bay from Sault Ste. Marie.
24	C. W. Ernst, Boston, Mass	Two hundred and seventy-four geographical positions of prominent places in the United States, and bibliographical references to positions and elevations of cities and towns in the United States.
27	Mr. Peter Witzel, Newark, N. J	City front of Newark and part of Passaic River, 1836 and 1858.

APPENDIX No. 4.

REPORT OF THE ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR THE YEAR ENDING JUNE 30, 1884.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1884.

SIR: I respectfully submit herewith my annual report from the office, with those from each division, showing the character and quantity of the work accomplished during the last fiscal year.

The very large amount of work performed in the Computing Division, as reported by Assistant C. A. Schott, in charge of it, attests the ability and industry of himself and all the persons employed under his direction.

The incessant calls made upon Assistant Schott to enable me to answer the almost daily requests from all parts of the country for information only obtainable from our records and computations have been invariably, promptly, and fully met.

I specially ask your attention to the large increase in calls for the isogonic charts of magnetic variation in the United States, published in your report of 1882, and the tables accompanying them.

The Engraving, Electrotyping, and Printing have continued in charge of Assistant H. G. Ogden. He reports that in addition to the regular work of the division there has been an unusual amount of additional labor in corrections to engraved plates consequent upon new surveys. About four hundred plates have required greater or less correction. Mr. Ogden refers to the death of Mr. A. Sengteller, who had been employed since 1856 and was one of our best engravers.

Mr. F. W. Benner also died in October last.

Increased efficiency has been obtained in the electrotype department, where a larger amount of work has been done by Dr. A. Zumbrock, under Mr. Ogden's direction, than in any previous year.

In the printing department a new press has been added. The demand for and consequent printing of charts has increased 16 per cent. during the year, while there has been so far no increase of force. Mr. Ogden awards great credit to Mr. Moore, foreman, and the other printers for their zealous and effective work. He also calls attention to the efficient services of Mr. J. H. Smoot, clerk of the division.

The report of the Tidal Division shows the usual amount of labor, under direction of Mr. R. S. Avery.

The new tide-predicting machine has been used with advantage and effect.

In the Drawing Division seventy special drawings and tracings have been furnished in answer to calls for information.

This has been in addition to the usual regular duties of the division, which has fully kept up with the field work of the season. I desire to notice specially the assistance I have received from Mr. W. T. Bright, clerk of the division, to whose labor and supervision much of the efficiency of the division is due.

The custody of the Archives has been in the hands of Mr. R. M. Harvey, who reports that the total number of records of every kind registered during the year has been two thousand and thirty-five, or one hundred and ninety-nine in excess of the previous year.

Mr. Saegmuller, Chief Mechanician, reports increased precision and efficiency in the dividing engine. A great improvement tending to increased precision in observation has been effected by supplying theodolites for the higher orders of triangulation, with telescopes of increased power. In all matters in his department I have been indebted to him for zealous co-operation in keeping our field parties well and sufficiently supplied with every means needed for effective work.

The report of Mr. M. W. Wines, chief of the Miscellaneous Division, gives a full account of the distribution and sale of the publications of the Survey.

In addition to this duty, Mr. Wines has had general charge of the office buildings, of the Carpenter Shop, and the Map mounting and Chart rooms.

Not only in these duties, but in other special and sometimes difficult duties, he has rendered zealous and efficient service, demanding special acknowledgment at my hands.

A new set of projection tables, based upon the Clarke spheroid and extending from the equator to the pole, is being computed, by your order, under my direction, and will soon be ready for the press.

At the request of the Commissioner of Agriculture a measurement has been undertaken of the areas of salt and fresh marsh upon the Atlantic coast. This is still going on.

Called here by you last January in consequence of the sudden and lamented death of my predecessor, Assistant R. D. Cutts, I found my labors lightened and an acquaintance with them facilitated by the method, system, and order introduced by my predecessors and prevailing in every department. Having served nearly forty years in field duty, I had but little acquaintance with office details, and I am indebted to every person with whom my duties have brought me in contact for kindly aid, each in his sphere, in enabling me to acquire that special knowledge needed in the position you have assigned me.

My thanks are specially due to Assistant H. W. Blair, assigned by you as my assistant in this office, where his familiarity with all the details of the position and his ability and unfailing courtesy made him of the very greatest service.

I beg also to acknowledge the assistance I have received from Mr. W. B. French, whose clerical duties have been promptly and efficiently discharged.

Yours, respectfully,

C. O. BOUTELLE,

Assistant, Coast and Geodetic Survey, in charge of Office and Topography.

Prof. J. E. HILGARD,

Superintendent United States Coast and Geodetic Survey.

REPORT OF THE COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1884.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,

Washington, June 30, 1884.

DEAR SIR: In conformity with regulations, I herewith respectfully submit the usual annual report of work done by the several computers during the fiscal year ending June 30, 1884.

The charge of the Computing Division has been continued with the undersigned, and no change took place in its personnel, though it required all the experience and energy of its members to keep up with the current work and to put the results of the older triangulations on the modern data demanded and adopted in February, 1880. No extra help was afforded this division during the year. During the temporary absence of the Assistant in charge of the office and topography, I was called upon to discharge those duties during October and November, and again between December 12, 1883, and January 7, 1884, on which last date I was relieved by Assistant C. O. Boutelle. By direction of the Superintendent I took charge of the magnetic observations made at the international polar station, Ooglaamie, Alaska, occupied during 1881, 1882, and 1883, directing the computations and reporting the results of the absolute and differential observations.

For this work special clerical aid was provided by the Chief Signal Officer. On December 19, 1883, Sergeant J. E. Maxfield and on January 21, 1884, Private G. W. Knopf reported for duty. The former continued with this division to the close of the year; the latter was relieved from this special duty May 11, 1884. On May 10, I submitted in duplicate a full report of the results obtained. After this I was engaged in completing a discussion of the hypsometric measures undertaken in 1880 by Assistant George Davidson in connection with the study of atmospheric refraction at Mount Diablo and Martinez East, Cal. My report on these results is dated June 5, 1884. These two reports are published as appendices to the Superintendent's annual report for 1883. The usual annual magnetic observations were made by me at the magnetic observatory in this city.

The charge of the duplicate records of the astronomical, geodetic, and magnetic observations was continued with this division. The calls on this branch of the office for certain scientific information required by office and field parties, in reply to official correspondence, when referred to this division, were promptly attended to. The registers of geographical positions in the Computing and Drawing Divisions were kept up to date, and needful information, geodetic and magnetic, for the charts issued by the Survey, was supplied. This division also attended to the annual statistics, astronomical, geodetic, and magnetic, and to proof reading of its scientific papers appearing in the annual report; examined for completeness of statement all astronomical, geodetic, and magnetic records, and reported the results reached by the several computers.

The work performed by each computer during the fiscal year is herewith given in detail.

Mr. Edward H. Courtenay attended to the geographical registers and the preparation of geodetic data or information called for by field parties or correspondence; computed and adjusted to the old work the new supplementary triangulations executed on the shores of Long Island Sound in Connecticut and Long Island, New York, by Assistants G. Bradford and S. C. McCorkle in 1881-'82-'83; assisted me in the completion and reduction of the absolute determinations for magnetic declination, dip, and intensity at Ooglaamie, Alaska, 1881-'82-'83; computed my magnetic observations at Washington, D. C, 1884, and those of Assistant Boutelle's party in New York, 1882-'83; completed the final adjustment of the main triangulation along the boundary of New York, Connecticut, and Massachusetts, 1862-'74; arranged for the new position computation of the triangulation of the Santa Barbara Islands, Cal., and made good progress with the final adjustment of and introduction of modern data for the main series of the Hudson River triangulation between 1851 and 1881, inclusive.

Mr. Myrick H. Doolittle adjusted the main triangulation of Pennsylvania and New Jersey, head of Chesapeake Bay to Trenton; prepared abstracts of the vertical angles of the primary triangulation (Davidson quadrilaterals) of California; computed the length of the Matagorda base, Tex., 1883, and connected the same with the triangulation of the coast; developed the triangulation of Pocomoke Sound and Chincoteague Bay near the Virginia and Maryland boundary on the latest data; computed the triangulation and traverse work of 1883 on the east coast of Florida, between Jupiter Inlet and Cape Florida, carrying the same data through the primary triangulation of the Keys to Card's Sound; computed the main triangulation connecting Lake Champlain with Lake Ontario, N. Y., 1880-'83, and forming a junction with the Lake Survey work near Oswego; computed the triangulation near Portland, Oreg., junction of Willamette and Columbia Rivers; introduced the standard geodetic data into the triangulation of Lake George, N. Y., 1872, and nearly completed the computation of the geographical positions of all tertiary points of Lake Champlain, 1870-'71-'72, basing them on the same data.

Mr. Jermain G. Porter revised the longitude computation of Falmouth, Ky.; supplied some geographical positions on the Savannah River, and in the vicinity of Louisville, Ky.; computed the position of McCormick's Observatory, Va.; assisted Mr. Doolittle in the solution of normal equations; developed the coast triangulation between Cape Henlopen and Cape Charles on the standard spheroid; revised the latitude computation of Carson Sink, Nev., and computed the following telegraphic differences of longitude: Baton Rouge, La., and Atlanta, Ga., 1880; San Diego and San Francisco, Cal., 1871; Los Angeles and San Francisco, Cal., 1870; Omaha, Nebr., and Denver, Colorado Springs, and Trinidad, Colo., 1873; computed the telegraphic longitudes of Paducah, Ky., Cairo, Ill., Hickman, Ky., and Memphis, Tenn.; also of Travis, Burt, and Finn, N. Y., 1877, of Harrisburg, Pa., 1877, and of Helena, Ark., Natchez, Greenville, and Vicksburg, Miss.,

1878; revised transit reduction at Auckland, New Zealand, 1882, and computed the following differences of telegraphic longitude: Washington and Cape May, N. J, 1881; Washington and Strasburg, Va., 1881; Washington and Cincinnati, 1881, Nashville and Cincinnati, 1881; Saint Louis and Cincinnati, 1881; Saint Louis and Nashville, 1881; Nashville and Vincennes, Ind., 1881; Saint Louis and Vincennes, 1881; Saint Louis and Kansas City, 1882; Saint Louis and Omaha, 1882; Kansas City and Omaha, 1882; and of Charlottesville, Va., and Washington, 1882. He also computed the time and azimuth of stations Lauderdale and Ten, in Eastern Florida, 1883, and assisted in the reduction of the astronomical observations made at Ooglaamie, Alaska, 1881–'82–'83.

Mr. Alexander S. Christie completed the computation for time and azimuth at Mount Tamalpais, Cal., 1882; prepared abstracts of results of spirit levels between Saint Louis and Etlah, Mo.; computed time and azimuth station Carson Sink, Nev., 1880; computed time and azimuth of Toiyabe Dome, Nev., 1880; computed time and azimuth of station Mount Callahan, Nev., 1881; computed time and azimuth of station Eureka, Nev., 1881; revised the latitude computations of Mount Callahan, Nev., of Tamalpais, Cal., and of Jefferson City, Mo.; computed the azimuths of Jefferson City, Mo., 1879, and of Hunter, Mo., 1880; revised the latitude computation of Eureka, Nev., and furnished mean places of stars for field and office parties.

Mr. Charles H. Kummell revised computation for vertical angles at stations Mount Diablo, Martinez East, 1880, and Round Top and Jackson's Butte, 1879; computed new or modern positions for the triangulation of Saint John's River, Fla., 1876–'77–'78, and a few supplementary positions coast of Massachusetts, 1875, and in Connecticut, 1882–'83; made a new position computation with improved length of base of the main triangulation of the Santa Barbara Channel, Cal., 1853 to 1878; computed a few supplementary positions triangulation of the Hudson River; assisted in taking hourly means of bifilar readings, Ooglaamie, Alaska; computed some points of the tertiary triangulation, coast of Oregon; computed the triangulation of Port Orchard, W. T., 1880, and made progress with similar work in Hood's Canal, W. T., 1881, 1882, and 1884.

Mr. Henry Farquhar completed the computation of the spirit levels between Saint Louis and Etlah, Mo.; computed the following astronomical latitudes: Toiyabe Dome, Nev., 1880; Jefferson City, Mo., 1879; Kansas City, Mo., 1882; Auckland, New Zealand, 1882; Mount Tamalpais, Cal., 1882, and Mount Callahan, Nev., 1881; was temporarily assigned to Assistant Smith's pendulum party between January 1 and March 6, and again between March 20 and May 1, 1884. He also computed the latitude of Eureka, Nev., 1881, and of Keeney, W. Va., 1880, and computed certain spirit levels, District of Columbia, 1880 and 1884.

Mr. Alexander Ziwet completed the computation connecting the triangulation of Suisun Bay with Mount Diablo, Cal., 1880; computed some supplementary geographical positions on the Connecticut River; assisted in miscellaneous revisions, checks, and verifications; assisted Mr. Courtenay in the computation of geographical positions of the supplementary triangulation of Long Island Sound and vicinity, 1881–'82–'83; revised the triangle sides and positions of the survey of San Diego Bay, Cal., 1851–'71; computed some geographical positions in West Virginia; supplied hourly means of the Ooglaamie magnetic differential readings, 1882–'83; assisted in the adjustment of the series of triangles along the New York, Connecticut, and Massachusetts boundary and along the Hudson River; assisted in checking hypsometric measures, California, and computed additional geographical positions on the islands of Santa Barbara Channel.

Mr. P. R. Stansbury attended to the clerical duties of the Computing Division, and chiefly to the geographical registers for the Drawing Division, the copying of reports, and of other geodetic matter for the use of field parties.

Mr. Edward A. Trescot was temporarily assigned to this division as copyist on April 3, and was chiefly engaged to the close of the fiscal year in completing the duplicate records of the Survey pertaining to geodesy.

I remain, sir, yours, respectfully,

CHAS. A. SCHOTT,
Assistant, in charge Computing Division.

C. O. BOUTELLE, Esq.,
Assistant, in charge of Office and Topography.

REPORT ON THE FIELD AND OFFICE WORK RELATING TO THE TIDES FOR THE YEAR ENDING JUNE 30, 1884.

U. S. COAST AND GEODETIC SURVEY OFFICE,
June 30, 1884.

DEAR SIR: I respectfully submit this report on the work of the Tidal Division, of which I have been in charge during the year.

OBSERVATIONS.

Self-registering tide-gauges have been used at the following stations: Pulpit Harbor, North Haven, Me.; Block Island, R. I.; New London, Conn.; Sandy Hook, N. J.; Saucelito, Cal.; Saint Paul, Kadiak Island, Alaska; and Honolulu, Sandwich Islands. In September, 1881, on requisition, the last supply of paper and blank forms was sent for use on the self-registering gauge loaned to the city engineers at Providence, R. I., and they promised to send to this office more of their observations soon, but no more have been received yet. A self-registering tide-gauge was sent nearly a year ago for use in the Delaware River, below Philadelphia, by the United States engineers, in accordance with an arrangement with them. The observations are to be for their use and also for the use of the Coast and Geodetic Survey. In September, 1883, on application from the officer in command of the artillery school at Fort Monroe, a self-registering tide-gauge was sent there, furnished with paper and blank forms for about a year, to be used by the students, the observations to be returned with the gauge.

I make no recommendations for occupying new stations with self-registering gauges at present, except by hydrographic parties for facilitating and improving the hydrographic work, arrangements for which are in progress; but the recommendations made in my last annual report are such as I would renew, if circumstances should at any time be deemed favorable.

In the following table I give a list of the observations received from self-registering gauges during the fiscal year, with the periods during which the several stations were occupied:

Section.	Name of station.	Name of observer.	Kind of gauge.	Permanent or temporary.	Time of occupation. From—	Time of occupation. To—	Total days.
I	Pulpit Harbor, Me.	J. G. Spaulding	Self-registering	Permanent	May 30, 1883	April 27, 1884	333
I	Block Island, R. I.	J. M. Conley	do	Temporary	July 1, 1883	January 19, 1884	223
II	New London, Conn.	A. Koch	do	do	July 1, 1883	November 20, 1883	143
II	Sandy Hook, N. J.	F. W. Shepheard	do	Permanent	July 1, 1883	June 30, 1884	366
X	Saucelito, Cal	E. Gray	do	do	July 1, 1883	June 30, 1884	366
XII	St. Paul, Alaska	W. J. Fisher	do	do	March 1, 1883	December 1, 1883	276
	Honolulu, S. I.	W. D. Alexander	do	Temporary	July 20, 1882	June 28, 1884	709

The observations at Block Island were stopped owing to the gauge being broken by a vessel running against the tide house. The observations at New London were stopped after having been continued a year. There are two self registering tide-gauges in the office for which clocks are wanting. The tidal observations made by the hydrographic parties of the Survey are inspected as soon as received, and reduced in the Tidal Division. Notices of them may be found in the statements of work done in the different sections. They are generally made with a staff or a box gauge, usually during daylight only, and sometimes quite irregularly. It is very desirable that such observations should be made more continuously, as there is liability to imperfect reduction of soundings, especially where there is only one tide in a day or large diurnal inequality.

OFFICE-WORK.

Most of the observers furnished with self-registering gauges have been taught to tabulate the high and low waters and hourly ordinates from the curves before sending these to the office, and then send the tables and curves at different times, thus preventing losses by mail and other acci-

dents. This mode of working has been found to make the observers more skillful and careful, and considerably reduce the amount of office-work. The results of the observations received from the self-registering gauges and hydrographic parties are used in prediction, chart making, and for other purposes. The reductions and discussions that have been made enable the division to furnish a large amount of information about tides to officers of the Survey, civil and United States engineers, and others, and the demand for it has been rapidly increasing. In Appendix No. 3 is included a statement of tidal data supplied to persons not connected with the Survey. Tide tables containing the predictions for the Atlantic and Pacific coasts of the United States for the year 1885 have been computed, and are in course of publication, making the nineteenth year of the series.

The following computers have been employed in this division in the course of the year: R. S. Avery, L. P. Shidy, M. Thomas, and C. B. Turnbull, in the office, and J. G. Spaulding out of it. Mr. Avery was in charge of the division, and inspected all the tidal observations when received, attended to the correspondence with observers and others relating to tides, planned and supervised the work on tides and tide-gauges, prepared the predictions for printing and read the proofs, and computed when not otherwise engaged. Mr. Shidy reduced many observations received from the self-registering gauges and hydrographic parties, predicted for some of the places where the old methods had to be used and with the predicting machine for others, prepared tables to be used in calculating components, and aided efficiently in miscellaneous work. Miss Thomas worked on the simplest reductions and on the hourly ordinates for permanent stations, aiding sometimes in miscellaneous work and copying. Miss Turnbull has been employed copying, tracing, tabulating tides, and sometimes aiding in miscellaneous work and easy reductions. Mr. Spaulding made predictions for some places in addition to his services as tidal observer at Pulpit Harbor.

Respectfully submitted.

R. S. AVERY,
In charge Tidal Division.

C. O. BOUTELLE, Esq.,
Assistant, in charge of Office and Topography.

REPORT OF THE DRAWING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1884.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1884.

DEAR SIR: The synopsis here presented of the work done in the Drawing Division under my supervision during the fiscal year ending June 30, 1884, will serve to show the character of the labor performed by each person connected with the division; and the summarized statement accompanying gives in detail abstracts of the year's results.

The charts that were completed or in progress, the plane-table sheets inked, and the miscellaneous drawings finished, together with the names of the draughtsmen who did the work, are given in the tabular statement appended.

Year by year, as the area covered by the survey increases, the calls on this division for special information, such as tracings, compilations, unfinished proofs brought up by hand, transcripts of records, &c., have grown; but yet, notwithstanding the pressure of its regular work, the division has met all these demands with faithful promptness. How various and numerous have been the calls, may be seen by referring to Appendix No. 3, in which those answered by the Drawing Division are included.

Forty maps and charts, embodying the several series of the catalogued publication class, have been in progress. Of this number eighteen were finished, twelve of them by photolithography, the latter including three minute carefully-drawn maps, illustrating the entire boundaries of all the custom districts of the United States, for the use of the Treasury Department. Thirty-four plane-table sheets were inked in the best manner, preparatory to reproduction by photolithographic processes; projections were constructed upon fifteen copper plates for the use of the engravers;

numerous drawings of instruments of precision, notably the perspective views of the Ferrel tide-predicting machine, and diagrams illustrating professional papers, were made for issue in the annual report; thirty-five projections for topographic work and forty-seven for hydrographic developments were constructed; progress was made upon the map of the United States, scale 10 miles to the inch, and an elaborate model, in plaster, of the Atlantic Basin and Gulf of Mexico, was finished.

The work, as usual, in this division has been of a diversified and difficult kind, and it affords me pleasure to testify to the faithful manner with which the draughtsmen, one and all, have performed the duties allotted to them, and to the high order of skill displayed by them in execution thereof. The personnel has remained unchanged.

Nearly all drawings have been inked with a view to reproduction, in order that any sudden call could be met at once.

To make delay as short as possible, preliminary editions of many new charts are now drawn for, and published by photolithography, immediately after the surveys are completed. These serve until the final engraved charts are issued, thus bringing the information they contain before the public without loss of time. The draughtsmen have become by experience quite expert in making photolithographic drawings, which require practical skilled knowledge in their execution to produce good prints.

The names of the draughtsmen, together with an outline of the distribution of work among them, are as follows:

Mr. A. Lindenkohl has been occupied in the construction of a minute topographical map of the United States, scale of 10 miles to the inch, but has found time to construct an accurate and elaborate model of the depths of the sea in the Bay of North America and the Gulf of Mexico, and to keep the progress sketches of the survey supplied with the latest information.

Mr. H. Lindenkohl has prepared the following photolithographic drawings: Hart and City Islands; San Pedro Harbor, Cal.; Destruction Island, W. T., and a new map of Alaska Territory, and also numerous reductions for the annual report.

Mr. C. Junken has devoted his time principally to the reduction of hydrography for engraving.

Mr. E. J. Sommer, who had been on leave of absence, returned to the office and resumed his position in the division in November. His work has been the making of projections on paper and copper, and reductions of topography and hydrography. He reduced Coast Chart No. 162, Cape Canaveral to Indian River Inlet, and prepared the photolithographic drawing for the chart of Black Rock Harbor.

Mr. T. J. O'Sullivan reduced the topography for Coast Chart No. 176, Charlotte Harbor to Tampa Bay, general lettering; and made the photolithographic drawings for charts of the inside passage of Indian River, and for progress of the transcontinental triangulation from the Pacific coast westward; also sketch of triangulation in Missouri and Illinois.

Mr. P. Erichsen, in addition to reducing the topography for Coast Chart No. 148, Bogue Inlet to New Topsail Inlet, inked five plane table sheets, verified engraved charts, and made a series of perspective drawings of the tide-predicting machine.

Mr. L. Karcher has been employed chiefly in making the numerous projections required by field parties, preparing projects and diagrams for office use, tracing and miscellaneous work.

Mr. Karcher was off duty March 29 to July 1.

Mr. A. B. Graham, while engaged almost exclusively in constructing hydrographic projections, plotting geographical positions, and transferring shore-line to projections made by other draughtsmen, has inked six topographical field sheets, and made tracings and diagrams of different kinds.

Mr. E. H. Fowler has continued to ink plane-table sheets, and during the year inked eleven sheets complete Mr. Fowler also made the smooth drawing for the photolithograph of Delaware Breakwater.

Mr. E. Molkow inked ten plane-table sheets, made reductions, compiled statistics, and prepared a few diagrams.

Mr. Barker has been employed in coloring buoys and light-houses and making additions and corrections upon the printed charts.

Mr. J. C. Barr has continued to be employed in the division. He has colored lights and buoys on charts, and made such corrections thereon as were necessary for the purpose of navigation, and has assisted in clerical duties.

Yours, respectfully,

W. T. BRIGHT.

C. O. BOUTELLE, Esq.,
Assistant, in charge of Office and Topography.

DRAWING DIVISION.

Charts completed or in progress during the year ending June 30, 1884.

1. Topography. 2. Hydrography. 3. Drawing for photolithographic reproduction. 4. Inking and lettering plane-table sheets. 5. Projections on copper. 6. Compiling. 7. Verification. 8. Diagrams. 9. Measuring area of engraved surfaces.

Catalogue number of chart.	Titles of charts.	Scale.	Draughtsmen.	Remarks.
	ATLANTIC COAST.			
	GENERAL COAST CHART.			
14	Cape Canaveral to Cape Florida	1-40,000	1, 2. A. Lindenkohl	Completed.
	COAST CHARTS.			
102	Seal Island Light to Petit Manan Light	1-80,000	1, 2. C. Junken	Continued.
111	Monomoy and Nantucket Shoals to Muskegat Channel	1-80,000	2. H. Lindenkohl	Additions.
114	Eastern Entrance to Long Island Sound	1-80,000	1, 2. H. Lindenkohl. 2. C. Junken.	Commenced.
120	New York Bay and Harbor	1-80,000	2. L. Karcher, C. Junken, E. Molkow.	Additions.
124	Delaware Entrance (lower sheet)	1-80,000	2. C. Junken	Do.
142	Roanoke Island to Hatteras Inlet	1-80,000	2. C. Junken	Do.
145	Cape Hatteras	1-80,000	6. T. J. O'Sullivan	Commenced.
148	Bogue Inlet to New Topsail Inlet	1-80,000	1. P. Erichsen	Completed.
150	Cape Fear River and approaches	1-80,000	1, 2. C. Junken	Do.
162	Cape Canaveral to Indian River Inlet	1-80,000	1. E. J. Sommer	Commenced.
175	Charlotte Harbor and San Carlos Bay	1-80,000	5. C. Junken	Do.
176	Charlotte Harbor to Tampa Bay	1-80,000	1. T. J. O'Sullivan	Do.
204	Galveston Bay	1-80,000	1, 2. H. Lindenkohl	Additions.
208	Pass Cavallo, Lavaca, and San Antonio Bays	1-80,000	5. H. Lindenkohl	Do.
209	Aransas Pass, Aransas and Copano Bays	1-80,000	5. H. Lindenkohl	Do.
210	Corpus Christi, southward	1-80,000	1. H. Lindenkohl. 5. C. Junken.	Completed.
	HARBOR CHARTS.			
305	Cape Split to Schoodic Island, Me	1-40,000	1. H. Lindenkohl. 2. A. Lindenkohl, E. J. Sommer.	Commenced.
344	Monomoy Passage	1-40,000	2. H. Lindenkohl	Additions.
359	New London Harbor, Conn	1-40,000	1. A. Lindenkohl. 2. L. Karcher, C. Junken.	Completed.
361	Hart and City Island	1-10,000	3. H Lindenkohl	Continued.
363	Black Rock Harbor	1-10,000	3. E. J. Sommer	Commenced.
369	New York Entrance	1-40,000	2. L. Karcher	Additions.
370	Delaware Breakwater	1-20,000	3. E H. Fowler	Do.
440	Savannah River and Warsaw Sounds	1-40,000	1, 2. E. J. Sommer	Do.
384	Patapsco River, Md	1-60,000	5. C. Junken	Commenced.
464e	Indian River—Elbow Creek to Rock Point	1-20,000	3. T. J. O'Sullivan	Do.
464f	Indian River—Rock Point to J. Kelley's house	1-20,000	3. T. J. O'Sullivan	Do.
464g	Indian River—Kelley's house to Bethel Creek	1-20,000	3. T. J. O'Sullivan	Do.
464h	Indian River—Bethel Creek to Indian River Inlet	1-20,000	3. T. J. O'Sullivan	Completed.
469	Key West Harbor	1-50,000	5. E. J. Sommer	Additions.
455b	Saint John's River, Jacksonville to Hibernia	1-80,000	9. P. Erichsen	Do.

DRAWING DIVISION—Continued.

Catalogue number of chart.	Titles of charts.	Scale.	Draughtsmen.	Remarks.
	PACIFIC COAST.			
	SAILING CHART.			
602	San Francisco to Umquah River	1-1, 250, 000	2. C. Junken	Continued.
	GENERAL COAST CHARTS.			
673	Point Conception to San Luis Obispo	1-200, 000	1. A. Lindenkohl. 5. C. Junken	Commenced.
675	Point Pinos to Bodega Head	1-200, 000	1. H. Lindenkohl	Additions.
677	Point Arena to Cape Mendocino	1-200, 000	5. C. Junken	Commenced.
	HARBOR CHARTS.			
610	San Pedro Harbor, Cal	1-20, 000	1, 2. A. Lindenkohl. 3. H. Lindenkohl.	Commenced.
669	San Luis Obispo Bay, Cal	1-20, 000	5. E. J. Sommer	Continued.
621a	San Francisco Bay, Entrance	1-40, 000	1, 2. C. Junken. 1. E. Molkow	Additions.
639[2]	Entrance to the Columbia River	1-40, 000	1. H. Lindenkohl, E. J. Sommer, 7. T. J. O'Sullivan.	Commenced.
662	Puget Sound, W. T	1-200, 000	A. Lindenkohl	Continued.
	Puget Sound, New Dungeness to Seattle	1-80, 000	1, 2. A. Lindenkohl	Commenced.
643	Destruction Island, W. T	1-40, 000	3. H. Lindenkohl	Additions.
	PLANE-TABLE SHEETS.			
	East Side Pleasant Bay, Me	1-10, 000	4. P. Erichsen, A. B. Graham	
	Pleasant Bay, Me	1-10, 000	4. E. H. Fowler	
	Jordan's River, Me	1-10, 000	4. E. Molkow	
	Millbridge Entrance to Cherryfield	1-10, 000	4. E. Molkow	
	New London and Vicinity	1-10, 000	4. E. Molkow	
	Hart and City Islands	1-10, 000	4. A. B. Graham	
	Western part of Long Island Sound	1-10, 000	4. E. Molkow	
	Hudson River, Haverstraw, northward	1-10, 000	4. E. Molkow	
	Hudson River, vicinity of Cold Spring	1-10, 000	4. E. H. Fowler	
	Hudson River, from Peekskill to Constitution Island	1-10, 000	4. E. Molkow	
	Hudson River, West Point	1-10, 000	4. P. Erichsen	
	New Jersey Coast, Hereford Inlet	1-10, 000	4. E. H. Fowler	
	Delaware Bay Shore	1-10,000	4. E. H. Fowler, E. Molkow	
	Delaware River—New Castle to Reedy Island	1-10,000	4. E. H. Fowler	
	Pocomoke Sound	1-10,000	4. P. Erichsen	
	Saint John's River, Fla. (reconnaissance)	1-80,000	4. A. B. Graham	
	Indian River, Fla	1-20,000	4. A. B. Graham, E. J. Sommer, P. Erichsen	
	East coast of Florida	1-10,000	4. A. B. Graham	
	Nueces Bay, Tex	1-20,000	4. E. H. Fowler	
	Laguna Madre, Tex	1-20,000	4. P. Erichsen	
	San Clemente Island, Cal	1-20,000	4. E. Molkow	
	San Nicolas Island, Cal	1-20,000	4. E. H. Fowler	
	Point Sur, Cal	1-10,000	4. E. H. Fowler	
	Tamalpais, Cal	1-10,000	4. C. Junken	
	Vicinity of Point Arguello, Cal	1-10,000	4. E. H. Fowler, A. B. Graham	
	Columbia River, Oreg	1-10,000	4. E. H. Fowler	
	Nestucca Bay Entrance, Oreg	1-10,000	4. E. Molkow	
	Sinslau Entrance, Oreg. (reconnaissance)		4. E. Molkow	
	Case's Inlet, W. T	1-10,000	4. E. H. Fowler	
	MISCELLANEOUS.			
	Customs map of United States, No. 1	1-5, 000, 000	6, 7. T. J. O'Sullivan	
	Customs map of United States, No. 2	1-1, 250, 000	6. L. Karcher; T J. O'Sullivan	
	Customs map of United States, No. 3	1-2, 500, 000	1. A. Lindenkohl; H. Lindenkohl.	
	Map of the Middle States	10 miles to 1 inch.	1. A. Lindenkohl; H. Lindenkohl.	
	Model of the Gulf of Mexico and Atlantic Basin		A. Lindenkohl; H. Lindenkohl.	
	Triangulation in Missouri and Illinois	1-800, 000	3. T. J. O'Sullivan	

DRAWING DIVISION—Continued.

Catalogue number of chart.	Titles of charts.	Scale.	Draughtsmen.	Remarks.
	MISCELLANEOUS—Continued.			
	Transcontinental triangulation, Pacific coast eastward	1-1,000,000	3. T. J. O'Sullivan	
	Transcontinental triangulation, east and west of Saint Louis, Mo.	1-1,000,000	3. H. Lindenkohl	
	Progress sketch of Southeast Alaska	1-2,500,000	6. H. Lindenkohl	
	New map of Alaska Territory	1-2,400,000	3. H. Lindenkohl	
	Small map of Alaska, for "Science"		H. Lindenkohl	
	Views for Alaska Coast Pilot		3. T. J. O'Sullivan (lettering)	
	Perspective drawings of tide-predicting machine		P. Erichsen	
	Plan of microscope, for weights and measures report		P. Erichsen	
	Diagrams of solar eclipse of January, 1880		3. T. J. O'Sullivan	
	Diagrams of coast charts		T. J. O'Sullivan	
	Diagrams of the estuary of the Delaware		3. T. J. O'Sullivan	
	Maps of boundary between Maryland and Pennsylvania		H. Lindenkohl.	
	Map of country between Harper's Ferry and Gettysburg		T. J. O'Sullivan	
	Diagrams of the Mississippi River and Galveston River jetties.		8. H. Lindenkohl and T. J. O'Sullivan.	

REPORT OF THE ENGRAVING DIVISION FOR THE YEAR ENDING JUNE 30, 1884.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1884.

SIR: I respectfully submit the following report of work executed in the Engraving Division during the fiscal year ending June 30, 1884:

In addition to the regular engraving we have had an unusual amount of cleaning electrotypes, erasures from altos, drawing and arranging titles, general lettering and notes, marking instruments, &c. The large amount of electrotyping done would naturally increase this class of work, but it has been still further augmented during the past year by the corrections required in bringing up new printing plates of many charts, the plates of which had become much worn. The corrections to the plates, required before printing for issue, have continued largely in excess of former years, and while we have only handled four hundred plates in this class of work, it has been most laborious, owing to the number of corrections arising from new surveys.

The force of engravers has been employed as follows:

Messrs. J. Enthoffer and R. F. Bartle on topography; Messrs. E. A. Maedel, A. Petersen, J. G. Thompson, and F. Courtenay on lettering; Messrs. W. A. Thompson and H. C. Evans on topography and sanding; Messrs. E. H. Sipe, W. H. Davis, and A. C. Ruebsam on lettering and miscellaneous corrections; Messrs. H. M. Knight and T. Wasserbach on sanding and miscellaneous corrections.

The Survey has lost the services of an expert engraver in the death of Mr. A. Sengteller, who died August 11, 1883. Mr. Sengteller was engaged in Paris in 1856, and immediately reported for duty in this office, where he remained continuously employed until his death, at the age of seventy. The many valuable charts published from the plates intrusted to him bear ample testimony to his artistic skill, fully sustaining the high recommendation given him when engaged for this special work on the survey. To within a few months of his death he was still faithful in his labors, and even his latest work, with old age and bodily infirmities oppressing him, evinces that refinement of treatment that brought him reputation in youth.

I have also to chronicle the death of Mr. F. W. Benner, on October 16, 1883. Mr. Benner had been employed for many years on "job work" at his home, and though physically incapable of engraving a large amount, what he did was satisfactory, and his death has proved a measurable loss in that class of work to which he confined himself.

The electrotyping of the copper plates has continued under my direction, with the immediate

supervision of Dr. A. Zumbrock, assisted by Frank Over. Some of the improvements referred to in my last annual report have been completed. Two cells and one vat have been added to the second battery, making it of equal capacity with the first. New rods for suspending the poles in the cells have been substituted since the close of the fiscal year, but sufficient observations have not yet been made to determine if they afford any particular advantage beyond that derived from rendering the batteries more easily taken care of.

The addition of two cells and the vat to one battery has necessarily increased the results of the year's work, but a larger increase has been obtained from a closer study and a more perfect knowledge of the requirements of the work as it is now carried on under my direction. This is seen at once in the quantity of copper deposited in comparison with that of previous years.

During October, November, and December, 1883, experiments were made by Mr. Werner Suess, under the direction of Assistant Schott, with a view of improving the galvanometer, but many trials demonstrated the system that had been in use to be the most reliable. A new instrument of more perfect workmanship, however, was made and set in place.

The printing for the chart room has increased 16 per cent. during the year. In the summer months the requisitions are greater than the capacity of our presses. This necessarily creates some delay in the delivery of charts, but it is not believed the delays are yet so great as to demand an increase of the force. The capacity of the printing establishment is the same as the preceding year, and much credit is due the foreman, Mr. F. Moore, and the other printers, for their endeavors to keep up the supply of charts during the busy season.

Mr. John H. Smoot has continued as clerk of the division. It gives me pleasure to commend him for the precision with which he keeps such a multiplicity of records, of late years largely augmented by the work of the printing and electrotyping.

Statistics of work.

ENGRAVING.

Number of plates completed:	
Charts	7
New editions of charts	10
Sketches and illustrations	36
Number of plates continued:	
Charts	20
Number of plates commenced:	
Charts	10
Sketches and illustrations	14
Number of plates corrected:	
Charts	400
Sketches	26
Number of unfinished plates on hand at the close of the year:	
Charts	44
Sketches and illustrations	29

ELECTROTYPING.

Number of pounds of copper deposited	2,582¼
Number of square inches on which deposit was made	113,628
Number of copper plates made:	
Basso	36
Alto	59

Of this number 4 basso and 4 alto plates were for the Engineer Corps, United States Army (Lake Survey plates), and 1 basso and 4 alto plates for the Hydrographic Office of the Navy Department.

There was also made a matrix of seal for the General Land Office.
In photographing, 27 negatives were made and 128 prints.

PRINTING.

Number of impressions for chart room	31,057
Number of impressions for Assistant in charge	9,530
Number of impressions for Engraving Division	2,315
Number of impressions for Hydrographic Inspector	1,148
Number of impressions for lithographers (transfer proofs)	96
Number of impressions for Atlantic Coast Pilot charts and views	1,665
Number of impressions for Alaska Coast Pilot views	5,226
Total	51,037

I append hereto a list of the copper plates that were completed, continued, or commenced during the year.

I remain, sir, yours, very respectfully,

HERBERT G. OGDEN,
Assistant, in charge of Engraving Division.

C. O. BOUTELLE, Esq.,
Assistant, in charge of Office and Topography.

Plates completed, continued, or commenced during the fiscal year ending June 30, 1884.

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering. 5. Etching.

Catalogue No.	Plate No.	Title.	Scale.	Engravers.
		COMPLETED.		
21	1090	Galveston to the Rio Grande	1–400,000	4. E. A. Maedel, H. M. Knight, and J. G. Thompson.
143	1190	Pamplico Sound, Middle Sheet, Ocracoke Inlet to Mouth of Pamplico River.	1–80,000	2, 3. H. M. Knight. 4. E. A. Maedel, J. G. Thompson, and W. H. Davis.
175	1093	San Carlos Bay to Lemon Bay, including Charlotte Harbor.	1–80,000	1, 2, 3. W. A. Thompson. 4. E. A. Maedel, A. Petersen, and J. G. Thompson.
182	1447	Apalachee Bay and Saint George's Sound	1–80,000	2. W. A. Thompson. 3. T. Wasserbach. 4. F. Courtenay, T. Wasserbach, J. G. Thompson, and A. C. Ruebsam.
195	1823	Mississippi River, Grand Prairie to New Orleans	1–80,000	4. E. A. Maedel and J. G. Thompson.
455*b*	1704	Saint John's River No. 3, Jacksonville to Hibernia	1–40,000	3. R. F. Bartle. 4. J. G Thompson.
455*c*	1729	Saint. John's River No. 4, Hibernia to Racey's Point	1–40,000	3. R. F. Bartle. 4. E. A. Maedel, F. Courtenay, and J. G. Thompson.
		NEW EDITIONS, 1883.		
154	1730	Long Island to Hunting Island	1–80,000	3, 4. H. M. Knight, J. G. Thompson, and A. C. Ruebsam.
626	1758	Suisun Bay	1–40,000	3. James H. Barker, T. Wasserbach. 4. W. A. Thompson, J. G. Thompson, and W. H. Davis.
		NEW EDITIONS, 1884.		
369[2]	1792	New York Entrance	1–40,000	1, 2. W. A. Thompson. 3, 4. H. M. Knight. 4. J. G. Thompson.
469	1736	Key West Harbor	1–50,000	3. James H. Barker, W. A. Thompson. 4. E. A. Maedel and A. C. Ruebsam.
520	1803	Galveston Entrance	1–40,000	3, 4. T. Wasserbach. 4. A. C. Ruebsam.
551	1278	Burlington Harbor, Vt.	1–10,000	4. W. H. Davis.
655	1817	Blakely Harbor	1–10,000	2, 3. T. Wasserbach. 2. W. A. Thompson. 4. T. Wasserbach.
		REISSUES, 1884.		
315*a*	1065	Inside Passage, Bath to Booth Bay	1–20,000	4. T. Wasserbach.
425	786	Cape Fear River, Federal Point to Wilmington	1–30,000	3, 4. T. Wasserbach.
634	1323	Cape Orford and Reef	1–40,000	2. W. A. Thompson. 4. E. H. Sipe.
		PROGRESS SKETCHES.		
	1745	Hudson and Saint Croix Rivers (extension)		1, 4. E. H. Sipe. 4. A. C. Ruebsam.
	1749	Maryland and Georgia Base Lines (extension)		4. E. H. Sipe and A. C. Ruebsam.
	1753	Long Island and the Blue Ridge (extension)		4. E. H. Sipe and A. C. Ruebsam.

Plates completed, continued, or commenced during the fiscal year ending June 30, 1884—Continued.

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering. 5. Etching.

Catalogue No.	Plate No.	Title.	Scale.	Engravers.
		ALASKA COAST PILOT CHARTS.		
	1565	Cape Mudge to Cape Commerell	....	4. E. H. Sipe and W. H. Davis.
	1566	Cape Commerell to Point Walker	....	4. E. H. Sipe and W. H. Davis.
	1567	Point Walker to Swanson Bay	....	4. E. H. Sipe and W. H. Davis.
	1568	Swanson Bay to Chatham Sound	....	4. E. H. Sipe.
	1569	Dixon Entrance	....	1, 4. E. H. Sipe and W. H. Davis.
	1570	Portland Canal and Observatory Inlet	....	4. E. H. Sipe.
	1571	Behm Canal and Clarence Strait	....	2. W. A. Thompson. 4. E. H. Sipe and W. H. Davis.
	1572	Wolf Rock to Cape Decision	....	2. W. A. Thompson. 4. E. H. Sipe and W. H. Davis.
	1573	Sumner Strait	....	2, 3. W. A. Thompson. 1, 4. E. H. Sipe. 4. W. H. Davis.
	1574	Fredericks Sound and Stephens Passage	....	1, 4. E. H. Sipe.
	1575	Sandy Bay to Cape Edward	....	2. W. A. Thompson. 1, 4. E. H. Sipe.
	1576	Cape Edward to Lituya Bay	....	2, 3. W. A. Thompson. 1, 4. E. H. Sipe.
	1819	Lynn Canal	....	2. W. A. Thompson. 1, 4. E. H. Sipe.
	1578	Lituya Bay to Yakutat Bay	....	2. W. A. Thompson. 1, 4. E. H. Sipe.
	1557	Seymour Narrows	....	4. E. H. Sipe and W. H. Davis.
		ALASKA COAST PILOT VIEWS.		
	1645	Sitka or Norfolk Sound	....	4. E. H. Sipe.
	1646	Anchorage Nass Bay, &c	....	4. E. H. Sipe.
	1644	Entrance to Coghlan Anchorage, &c	....	4. E. H. Sipe.
	1647	False Egg Island, &c	....	4. E. H. Sipe.
	1665	Invisible Point &c	....	4. E. H. Sipe.
	1663	Leading marks over Nahivitti Bar, &c	....	4. E. H. Sipe.
	1791	Point Craven, North Point of Peril Strait, &c	....	5. John R. Barker. 4. E. H. Sipe.
	1795	Point Windham, &c	....	5. John R. Barker. 2. W. A. Thompson. 4. E. H. Sipe.
	1796	New Eddystone Rock, &c	....	5. John R. Barker. 4. E. H. Sipe.
	1826	Mount Saint Elias and Mount Fairweather	....	5. E. H. Fowler. 4. E. H. Sipe.
		MOUNT DESERT ISLAND VIEWS.		
	1580	Robinson's Mountain, from summit of Brown's Mountain.	....	4. W. H. Davis.
	1549	Robinson's Mountain, looking north, Eagle Cliff Mountain.	....	2. W. A. Thompson. 4. W. H. Davis.
	1510	Brown's Mountain, looking northwest	....	4. W. H. Davis.
	1511	North Summit, face of Echo Mountain	....	2. W. A. Thompson. 4. W. H. Davis.
	1513	Brown's Mountain looking south	....	4. W. H. Davis.
	1546	Echo Mountain, looking west	....	2. W. A. Thompson. 4. W. H. Davis.
		TOPOGRAPHICAL VIEWS.		
	1700	Cape Disappointment, from Sandy Island, looking west	....	4. W. H. Davis.
	1691	The Dalles, Columbia River, looking southeasterly	....	4. W. H. Davis.
		COMMENCED.		
14	1778	Cape Canaveral to Fowey Rocks	1-400,000	1, 2. R. F. Bartle. 1, 3, 4. H. M. Knight. 4. E. A. Maedel and F. Courtenay.
152	1787	Winyah Bay, Cape Romain, &c	1-80,000	1, 2. J. Enthoffer. 4. A. Petersen.
210	1779	Corpus Christi Bay and Pass	1-80,000	1, 2. H. C. Evans. 4. J. G. Thompson.
305	1821	Pleasant Bay to Prospect Harbor, Me	1-40,000	1, 2. R. F. Bartle.
359a	1798	Thames River and New London Harbor	1-40,000	1, 2. R. F. Bartle. 4. A. Petersen and J. G. Thompson.
673	1800	Point Conception to San Luis Obispo	1-200,000	1, 2. W. A. Thompson.
676	1741	San Francisco to Point Arena	1-200,000	1, 2. W. A. Thompson. 4. A. Petersen.
681a	1799	Approaches to the Columbia River	1-200,000	1, 2. J. Enthoffer. 4. A. Petersen.
654a	1762	Port Discovery and Washington Harbor	1-40,000	1, 2. E. J. Enthoffer. 4. F. Courtenay.
669	1828	San Luis Obispo Bay	1-20,000	1, 2. E. J. Enthoffer.
	1789	Trinidad Harbor	1-40,000	1, 2. E. J. Enthoffer. 3. H. C. Evans and W. A. Thompson. 4. F. Courtenay.
	1793	Saint George's Reef and Crescent City	1-80,000	1, 2. E. J. Enthoffer. 3. H. M. Knight. 4. F. Courtenay.
	1793	Cape Orford and Reef	1-80,000	1, 2. E. J. Enthoffer. 3. H. M. Knight. 4. F. Courtenay
	1820	San Diego Bay	1-100,000	1, 2. E. J. Enthoffer. F. Courtenay.
	1805	San Francisco Bay	1-80,000	1, 2. E. J. Enthoffer. 3, 4. H. M. Knight.
	1782	Map of United States—Pennsylvania and New Jersey	1-10,000	1, 2, 4. A. C. Ruebsam.
	1819	Alaska Coast Pilot chart, Lynn Canal	....	1, 4. E. H. Sipe. 2. W. A. Thompson.

Plates completed, continued, or commenced during the fiscal year ending June 30, 1884—Continued.

1. Outline. 2. Topography. 3. Sanding. 4. Lettering. 5. Etching.

Catalogue No.	Plate No.	Title.	Scale.	Engravers.
		COMMENCED.		
	1763	Atlantic Coast Pilot view, Volume 4, Duck Key, Sombrero Key, &c.	....	5. John R. Barker.
	1765	Atlantic Coast Pilot view, Volume 4, Dames Point, Saint John's River, &c.	....	5. John R. Barker.
	1781	Atlantic Coast Pilot view, Vol. 4, Green Cove Springs, &c.	....	5. John R. Barker.
	1788	Atlantic Coast Pilot view, Vol. 4, Entrance to Saint Augustine, &c.	....	5. John R. Barker.
	1791	Alaska Coast Pilot view, Point Craven, North Point of Peril Strait, &c.	....	5. John R. Barker.
	1795	Alaska Coast Pilot view, Point Windham, approaches to Takon Harbor, &c.	....	5. John R. Barker.
	1796	Alaska Coast Pilot view, Northwest Point of Washington Islands.	....	5. John R. Barker.
	1826	Alaska Coast Pilot view, Mount Saint Elias and Mount Fairweather.	....	5. E. H. Fowler.
		CONTINUED.		
D	1053	Sailing chart, Gulf of Mexico	1-2, 100, 000	4. E. A. Maedel.
102	1742	Seal Island to Petit Manan, north part	1-80, 000	1 and 2. J. Enthoffer.
145	1725	Cape Hatteras	1-80, 000	1 and 2. R. F. Bartle. 3. H. C. Evans. 4. A. Petersen.
152	1787	Winyah Bay, Cape Romain, &c	1-80, 000	1 and 2. J. Enthoffer.
153	1503	Winyah Bay to Long Island	1-80, 000	4. H. M. Knight.
180	1746	Cedar Keys to Dead Man's Bay	1-80, 000	1 and 2. H. C. Evans. 4. F. Courtenay.
181	1450	Apalachee Bay	1-80, 000	3. F. Courtenay.
192	1537	Chandeleur and Breton Island Sounds	1-80, 000	3. F. Courtenay.
204	1316	Galveston Bay	1-80, 000	4. F. Courtenay.
208	1247	Pass Cavallo, Lavaca and San Antonio Bays	1-80, 000	3. F. W. Benner. 4. T. Wasserbach and A. C. Ruebsam.
209	1248	Aransas Pass, Aransas and Copano Bays	1-80, 000	2 and 3. W. A. Thompson. 3. F. W. Benner, H. C. Evans. 4. A. C. Ruebsam.
212	1715	Brazos Santiago, &c	1-80, 000	3. James H. Barker.
306	1186	Frenchman's Bay and Somes Sound	1-40, 000	2 and 3. H. C. Evans, W. A. Thompson. 4. A. Petersen and E. H. Sipe.
307	1265	Blue Hill and Union River Bays	1-40, 000	3. H. C. Evans. 4. A. Petersen and E. H. Sipe.
308	1376	Approaches to Blue Hill Bay and Eggemoggin Reach	1-40, 000	3. H. C. Evans. 4. A. Petersen.
359*a*	1798	Thames River and New London Harbor	1-40, 000	1 and 2. R. F. Bartle. 4. A. Petersen. 3. H. M. Knight.
401*c*	1679	James River No. 5, Kingland's Creek to Richmond	1-20, 000	4. F. Courtenay.
600*a*	1754	San Diego to San Francisco	1-1, 200, 000	1 and 4. H. M. Knight.
600*b*	1755	San Francisco Bay to the Stait of Juan de Fuca	1-1, 200, 000	1 and 4. H. M. Knight.
621*a*	1532	San Francisco entrance	1-40, 000	1 and 2. W. A. Thompson. 3. H. M. Knight. 4. J. G. Thompson and A. Petersen.

REPORT OF THE MISCELLANEOUS DIVISION FOR THE YEAR ENDING JUNE 30, 1884.

U. S. OFFICE COAST AND GEODETIC SURVEY,
Washington, June 30, 1884.

SIR: I have the honor to submit herewith the annual report of this division for the year ending June 30, 1884.

The general work of the division was the same as in former years. The Annual Reports for the years 1881 and 1882 were printed during the year, thus bringing the series much nearer to current date than for many years previous. The Annual Report for 1883 was also sent to press, and considerable progress made towards its publication. This volume will be ready for distribution before the Report for 1884 is submitted to Congress, when the whole series of annual reports will be up to date. For this much-desired result the office is largely indebted to the cordial co-operation of the Government Printing Office officials.

The first edition of Subdivision 15 of the Atlantic Coast Pilot (Delaware Bay and River) was published, and the Pacific Coast Pilot, Alaska, Part 1 (Dixon Entrance to Yakutat Bay, with the Inland Passages) was sent to press.

During the year the following aggregates of publications of the Survey were received from the Public Printer:

	Copies.
Annual Reports for 1879, 1880, 1881, and 1882	9,463
Appendices to Annual Reports (extra copies)	5,400
Tide Tables for the Atlantic and Pacific coasts for 1885	4,500
Notices to Mariners, Nos. 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51	6,000
Atlantic Local Coast Pilot, Subdivision 15	500
Summary of Report of Superintendent for 1883	300
List of Original Topographic and Hydrographic Sheets	100

A detailed statement concerning the above-mentioned publications is appended hereto.

Distribution of the various publications of the Survey to the Departments of Government, institutions, and individuals was made as usual, and the Notices to Mariners and Appendices to the Annual Reports, published in pamphlet form, were distributed gratuitously in the customary manner.

Three thousand three hundred and twenty-two copies of the Annual Reports were distributed during the year; also 856 copies of the Atlantic Coast Pilot, including subdivisions.

There were received in the chart-room during the year 33,743 sheets of charts, of which 28,198 were copper-plate impressions, and 5,545 were printed from stone. Thirteen thousand three hundred and forty-seven copies were furnished to the several Executive Departments and to Senators and Representatives, and 17,418 sheets were supplied to sale agents. The total issue of charts during the year was 33,638 copies, being an increase of 1,626 copies over the preceding year. (See statement appended hereto.) The receipts from sales of publications amounted to $3,966.44, which sum was duly deposited in the Treasury.

The issue of charts was made under the immediate supervision of Mr. Hugo G. Eichholtz, who has continued in charge of the chart-room.

The carpenter work of the office, including the wood work of instruments and packing them for transportation, the construction of vats, frames, &c., for the laboratory, repairs of furniture, and repairs to the office building, &c., was under charge of Mr. A. Yeatman up to the time of his death, on the 2d of December, 1883. Mr. H. O. French was appointed by the Superintendent to succeed Mr. Yeatman, and reported for duty on the 1st of January, 1884, since which date he has been in immediate charge of the carpenter shop. Messrs. G. F. Cox and G. W. Clarvoe were employed, as heretofore during the whole year, and rendered faithful and efficient service to the chief carpenter.

The map-mounting room has been in charge of Mr. R. T. Bassett, as heretofore, and Mr. N. Y. Cavitt has continued to discharge the duties of janitor.

The messengers and laborers employed in the office have discharged their duties with a degree of fidelity and zeal that entitles them to commendation.

Yours, respectfully,

M. W. WINES,

Chief of Miscellaneous Division.

C. O. BOUTELLE, Esq.,

Assistant, in charge of Office and Topography.

List of publications of the Coast and Geodetic Survey received from the Public Printer during the fiscal year ending June 30, 1884.

Name of publication.	Number of copies.
Annual Report for 1879	884
Annual Report for 1880	822
Annual Report for 1881	3, 845
Annual Report for 1882	3, 912
Tide Tables, Atlantic Coast, for 1885	2, 500
Tide Tables, Pacific Coast, for 1885	2, 000
Atlantic Coast Pilot, Subdivision 15—Delaware Bay and River.	500
Summary of Report of Superintendent for 1883	300
List of original topographic and hydrographic sheets registered in the Archives of the United States Coast and Geodetic Survey.	100
NOTICES TO MARINERS.	
No. 40—Dangerous rock off Warren's Point, R. I	500
No. 41—Dangerous rock recently reported on the coast of Maine, near Muscongus and Booth Bays.	500
No. 42—Rocks reported in Eggemoggin Reach, Me., and in East River, N. Y., near North Brother and Riker's Islands.	500
No. 43—Dangerous shoals off Cape Henlopen, Del	500
No. 44—Wreck in Potomac River, near Blackistone Island.	500
No. 45—Dangerous shoals in Monomoy Passage	500
No. 46—Notes on dangers in Neva and Peril Straits and anchorages in Fish Bay, Southeastern Alaska.	500
No. 47—Dangerous ledges in Fisher's Island Sound	500
No. 48—Dangerous rock in East River, N. Y	500
No. 49—Dangerous ledge in Englishman's Bay, coast of Maine.	500
No. 50—Development of ledges off Minot's light-house, Massachusetts Bay.	500
No. 51—Important changes at and near Cape Henlopen	500
APPENDICES TO THE REPORT FOR 1882.	
No. 7—A new compensating primary base apparatus, including the determination of the length of the corresponding five-meter standard bars.	500
No. 8—Measurement of the Yolo base, Yolo County, Cal.	200
No. 9—Field-work of the triangulation, third edition	700
No. 10—On the construction of observing tripods and scaffolds.	200
No. 11—Results of the transcontinental line of geodetic spirit-leveling near the parallel of 39°.	200
No. 12—Secular variation of the magnetic declination in the United States and at some foreign stations, fifth edition.	500
No. 13—Distribution of the magnetic declination in the United States at the epoch January, 1885.	800
No. 14—Records and results of magnetic observations made at the charge of the "Bache fund" of the National Academy of Sciences, from 1871 to 1876.	100
No. 15—Comparison of the survey of Delaware River of 1819, between Petty's and Tinicum Islands, with more recent surveys.	100
No. 16—Study of the effect of river bends in the Lower Mississippi.	100
No. 17—Discussion of the tides of the Pacific Coast of the United States.	500
No. 18—Report on the Siemens electrical deep-sea thermometer.	200
No. 20—The total solar eclipse of January 11, 1880, observed at Mount Santa Lucia, Cal.	100
No. 21—A new reduction of La Caille's observations of Fundamental stars in the southern heavens, 1749-1757.	200
No. 22—Report of a conference on gravity determinations	200
No. 24—Tribute to the memory of Carlile P. Patterson, Superintendent of the Coast and Geodetic Survey from 1874 to 1881.	300
APPENDIX TO THE REPORT FOR 1883.	
No. 7—Table of depths for harbors on the coasts of the United States.	500

Charts received in and issued from the chart-room during the fiscal year ending June 30, 1884.

To whom issued.	Number of sheets.			
	Received.	Issued.	On hand.	
			July 1, 1883.	June 30, 1884.
	33, 743		35, 771	35, 876
Executive Departments		12, 248		
Senators and Representatives		1, 099		
Institutions		1, 188		
Foreign Governments		149		
Sale agents		17, 418		
Miscellaneous		1, 536		
Total	33, 743	33, 638	35, 771	35, 876

ARCHIVES—UNITED STATES COAST AND GEODETIC SURVEY OFFICE.—REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1884.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1884.

SIR: I respectfully submit herewith the annual report of the receipt and registry in the Archives of all original and duplicate records and computations, original topographic and hydrographic sheets, and specimens of sea-bottom, turned into the office during the fiscal year ending June 30, 1884.

I.—*Records and computations.*

GEODETIC WORK.

	Number of volumes.			
	Original.	Duplicate.	Computations.	Total.
Observations of horizontal angles or directions	153	133		286
Observations of vertical angles	44	42		86
Descriptions of stations	22	19		41
Measurement of bases	6	4		10
Spirit-leveling	32	27		59
Geodetic miscellany	38	33		71
Computations			171	171
Total				724

ASTRONOMICAL WORK.

Observations for latitude	17	17		34
Observations for longitude	38	11		49
Observations for time	19	22		41
Observations for azimuth	5	10		15
Astronomical miscellany	8	4		12
Computations			64	64
Total				215

MAGNETIC WORK.

Observations of terrestrial magnetism	27	25		52
Computations			6	6
Total				58

HYDROGRAPHIC WORK.

Observations for soundings	286	176		462
Observations of angles	27	20		47
Descriptions of hydrographic signals	3	1		4
Specimens of sea-bottom	246			246
Tidal observations	130	84		214
Total				973

II.—*Topographic and hydrographic surveys.*

TOPOGRAPHIC WORK.

	Number of sheets.
ORIGINAL TOPOGRAPHIC SHEETS.	
Shores of Delaware River	3
Coast of Florida from Biscayne Bay northward	1
Shores of Saint John's River, Fla	1
Shores of Nueces Bay, Tex	1
West shore of Hudson River, N. Y	1
Western shore of Long Island Sound, N. Y	2
East shore of Hudson River, N. Y	2
Shores of Sarasota Bay, Fla	2
Shores of Lemon Bay, Fla	2
The Narraguagus Valley, Me	1
From Point Conception to Point Arguello, Cal	2
Shores of Harrington River and Bay, Me	1
Shores of Union River Bay and Skillings River, Me	1
San Nicolas Island, Cal	1
Shores of Pleasant Bay and River, Me	1
Point Sur to Kasler's Point, Cal	1
Cooper's Point to Point Sur, Cal	1
San Clemente Island, Cal	1
North shore of Long Island Sound, Conn	1
Shores of Carr's Inlet and Pickering Passage, W. T	1
Total	27

HYDROGRAPHIC WORK.

ORIGINAL HYDROGRAPHIC SHEETS.	
Approaches to New York Harbor, N. Y	1
Soundings off east shore of Gardiner's Island, N. Y	1
Croatan Sound, N. C	1
Saint John's River, Fla	3
Gardiner's Bay, N. Y	1
Delaware Bay, Del	1
East coast of Florida	4
Coast of Louisiana	1
Entrance to Cape Fear River, N. C	1
Pacific coast, from Point Pinos to Cooper's Point, Cal	5
Off Cape Romain, S. C	1
Manatee River Bar, Fla	1
West coast of Florida	2
Coast of Texas	2
Offshore soundings, coast of Long Island, N. Y	1
Sarasota Bay, Fla	2
Long Island Sound, N. Y	1
City Island Harbor, N. Y	1
Examination of the Gulf Stream, Atlantic coast	1
Lines of deep-sea soundings and serial temperatures, Atlantic coast	3
Profile of the Caribbean Sea	1
Swash Channel, New York Lower Bay, N. Y	1
Hatteras Inlet Bulkhead, N. C	1
Lower Delaware Bay, Del	1
Total	38

The foregoing exhibit shows that there were registered in the Archives during the past fiscal year 724 volumes of geodetic observations and computations; 215 volumes astronomical observations and computations; 58 volumes magnetic observations and computations; 974 volumes hydrographic observations and specimens of sea bottom; 27 original topographic sheets, and 38 original hydrographic sheets, making a total in volumes, specimens, and sheets combined of 2,035, or 199 in excess of the registry during the previous fiscal year.

Respectfully submitted.

RICH. M. HARVEY,
Custodian.

C. O. BOUTELLE, Esq.,
Assistant, in charge of Office and Topography.

REPORT OF WORK DONE IN THE INSTRUMENT DIVISION DURING THE YEAR ENDING JUNE 30, 1884.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1884.

DEAR SIR: I have the honor to submit herewith the annual report of this division for the year ending June 30, 1884.

The work of this division includes the keeping of the records and the correspondence relating to the receiving and forwarding of instruments, their safe-keeping, and their repairs and adjustment. Examination is made as soon as possible of all instruments returned by field parties. Those

found to be in good order are sent to the fire-proof building; those needing repairs are put in hand in the instrument shop. As heretofore, a great part of my time was occupied with the perfecting of the dividing engine, and in graduating a number of instruments. The divisions on a great number of our older theodolites and sextants have by long usage become so injured and indistinct that to make them useful they had to be regraduated. In a majority of cases this involved also the insertion of new silver bands, the old ones being too thin to admit of their being turned off true, and this had to be done especially with circles that had suffered a fall.

A great number of instruments were also supplied with new and more powerful telescopes, the increased accuracy of the graduation making an increase in the telescopic power desirable. Our old sextants not being originally supplied with the low-power telescopes, which the new ones possess, it was deemed advisable to supply these telescopes, as far as practicable, to all of the sextants; this has been done, and the greater part of our sextants are now thus provided. In order to be able to furnish, without delay, new mirrors to replace injured ones, it was found to be a great convenience to have a uniform standard size of mirror for all sextants. We have therefore changed a number of our older mirror mountings to conform to those on the new ones, and new mirrors can now be sent out without having to grind them to an odd size. Mr. John Clarke was on duty with the Coast Survey exhibit at the Louisville Exposition, and was away from the office for nearly four months. As heretofore, Mr. Clarke had the repairing of the magnetic instruments, levels of precision, longitude instruments, and the ruling of glass diaphragms. In addition he reconstructed the old 18-inch theodolite No. 4 (Troughton & Simms), which also received a new graduation. He also made from my design a double-image micrometer, which is used as a dynameter to measure the magnifying power of telescopes.

Mr. E. Eshleman assisted me in getting instruments ready for the field; he also kept record of boxes received and delivered. He has had charge of the theodolites, plane tables, and sextants, and prepared the greater number of the circles for regraduation.

Mr. P. Vierbuchen has overhauled the base bars, and asssisted in their comparison; he also repaired the protractors and made 24 new night signal-lamps. In connection with Louis Fischer he made the new 100-foot comparator, by means of which we can now compare our meter chains, and tape lines.

Mr. Louis Fischer assisted me very ably while working on the dividing engine in taking micrometer readings and in centering circles. He also prepared the silver surfaces of a number of circles for regraduation. Whenever the time permitted he worked on the automatic level-grinder. He has also mounted several new reconnoitering telescopes and attached heliotrope fixtures.

Mr. S. Kearney has made a number of new heliotropes and repaired the old ones; these are also being changed to have mirrors of standard size for all. In addition to these duties he has repaired drawing instruments, supplied the needed brass work for stands and telemeters, and executed miscellaneous office work.

Yours, respectfully,

G. N. SAEGMULLER,
Chief Mechanician.

C. O. BOUTELLE, Esq.,
Assistant, in charge of Office and Topography.

APPENDIX No. 5

REPORT OF THE HYDROGRAPHIC INSPECTOR FOR THE YEAR ENDING JUNE 30, 1884.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, October 1, 1884.

DEAR SIR: I have to submit my annual report of the progress of the hydrography, care and construction of vessels, and work incidental thereto, with which I am charged, for the fiscal year ending June 30, 1884.

HYDROGRAPHY.

The progress of the work is represented in detail in the reports of the officers in charge of hydrographic parties, who have mostly been detailed from those assigned by the Navy Department for Coast Survey duty.

It may not be inappropriate, however, to present a synopsis of the work done, in order that a more comprehensive view may be had of what was accomplished during the year.

Owing to the complete exhaustion of the appropriation for the previous fiscal year most of the parties could do but little more than make an attempt at fitting out in time to take the earliest possible advantage of the new appropriations. In most cases it was necessary to wait until the actual commencement of the year (July 1) in order that means might be available for the transportation of the parties, thus delaying the survey until the middle of the working season.

May and June on our northern coast are usually the most favorable months for surveying purposes. The expenses for fitting vessels are nearly the same for a short season as for a long one, and as appropriations made by Congress are only sufficient for about four months' work we thus lose these two best months in the year. Furthermore, the hydrographic parties are composed of men detailed from the Navy, and their experience is necessary for a proper execution of the work. They are retained as far as practicable from year to year, but while unemployed from a want of proper appropriations they are an unavoidable expense to the Government.

I would recommend that when Congress proposes in the future to reduce the amounts which you deem requisite for carrying on the various surveys, that it be requested to reduce the number of subdivisions in the estimates, or authorize a greater limit than ten per cent., to the transfer account. This would permit a more economical administration of the funds, with fewer parties, and with fully as good results as at present. It is believed it would not, however, enable the Survey to comply with the demands made on it from the commerce of the country for which extra appropriations are needed.

The commencement of the fiscal year found the vessels situated as follows:

The steamer Blake, Lieut. Commander W. H. Brownson, U. S. N., commanding, at work off New York entrance.

The steamer A. D. Bache, Lieut. H. B. Mansfield, U. S. N., commanding, at New York, preparing for summer season off New York entrance.

The steamer Gedney, Lieut. E. M. Hughes, U. S. N., commanding, at sea, making passage to the coast of Maine for summer season's work.

Steamer Endeavor, Lieut. John T. Sullivan, U. S. N., commanding, at sea, making passage to Long Island Sound, to continue its resurvey.

The schooner Eagre, Lieut. E. D. F. Heald, U. S. N., commanding, making passage to coast of Maine, to continue the hydrography in that vicinity.

The schooner Silliman, Lieut. John D. Keeler, U. S. N., at New York, preparing as one of the parties for the resurvey of Long Island Sound.

Schooner Drift, Lieut. J. C. Fremont, jr., U. S. N., commanding, at New York, preparing for current observations off New York entrance.

The schooner Ready, Lieut. C. McR. Winslow, U. S. N., commanding, at New York, preparing for work in Delaware Bay.

Steamer Arago, Lieut. G. C. Hanus, U. S. N., commanding, at work in Delaware Bay.

Schooner Scoresby, Assistant Charles Hosmer in charge, on topography and hydrography at Hart and City Islands, Long Island Sound.

The schooner Palinurus, Lieut. A. V. Wadhams, U. S. N., commanding, at work in Fisher's Island Sound.

The steamer Hassler, Lieut. Commander Henry E. Nichols, U. S. N., surveying waters of Alaska.

The steamer McArthur, Lieut. E. D. Taussig, U. S. N., commanding, at San Francisco, preparing for a summer's season on the California coast.

The schooner Earnest, Lieut. T. Dix Bolles, U. S. N., commanding, making a resurvey of Gray's Harbor, W. T.

The remaining vessels of the Survey were laid up or undergoing repairs. Lieut. E. M. Hughes' term having expired, he was relieved from duty in the Coast Survey, and succeeded in command of the steamer Gedney by Lieut. Commander A. S. Snow, U. S. N., who finished the season's work on the coast of Maine which was commenced by Lieutenant Hughes. No other change was made in the commanding officers of the vessels during the summer season.

The steamer Blake, after completing the offshore soundings in the approaches to New York, resurveyed Monomoy Passage and Black Rock Harbor, Conn., and made several special examinations of reported rocks and dangers.

The Scoresby, after finishing the survey of Hart and City Islands Harbor, continued work in the vicinity of the eastern end of Long Island Sound and in Shelter Island Harbor.

The parties in the field continued until about October 15, when they were withdrawn to prepare for their winter season in Southern waters. This time was taken to make some changes in the organization of the parties, necessitated by the expiration of the terms of service of some of the naval officers attached to the survey.

Lieut. Commander H. E. Nichols, U. S. N., was detached from the command of the steamer Hassler and Lieut. Commander A. S. Snow, ordered to relieve him. Lieut. E. D. F. Heald, was transferred from the Eagre to the command of the Gedney. Lieutenant Heald's health breaking down, he was only able to retain command of the Gedney until May, when he was detached from the vessel, and Lieut. G. C. Hanus was transferred from the Arago to fill the vacancy.

During the winter the party on the steamer A. D. Bache was engaged in hydrography on the west coast of Florida, finishing the season by an unsuccessful search for sunken wires laid off the Florida Reefs in 1868, for the purpose of ascertaining the rate of coral growth.

The party on board the steamer Gedney was surveying the coast of Texas and Louisiana to the eastward of Galveston entrance. The party on board the steamer Arago, with Lieut. G. C. Hanus, U. S. N., in charge, was engaged in surveying Back Bay, North, and North Landing Rivers, N. C., and later under Lieut. J. E. Pillsbury, U. S. N., making special Coast Pilot examinations from Cape Henry to Fernandina.

The party on board the schooner Drift was engaged in making current observations and special Coast Pilot examinations in the Gulf Stream and along the southern coast.

A party on board the steamer Barataria, under charge of Assistant Charles Hosmer, was on topography and hydrography in the bayous of Louisiana.

The schooner Quick, in charge of Sub-Assistant Joseph Hergesheimer, was used for his party while executing a topographical survey of the west coast of Fla.

The party on board the sloop Steadfast, in charge of Assistant B. A. Colonna, finished the survey of the Indian River and Lake Worth, Fla.

On the Pacific coast the party on board the steamer McArthur was engaged in hydrographic surveys on the California coast, in the vicinity of Point Buchon and between Salmon Point and Brushy Point.

At the end of the fiscal year the following vessels were preparing for the summer season's work in the northern waters of the Atlantic coast: The steamers Blake, Bache, Gedney, and Endeavor, and the schooners Eagre, Drift, Ready, and Palinurus; and on the Pacific coast the steamers Hassler and McArthur.

The schooner Earnest, after laying up all winter, was prepared for work in Puget Sound, and proceeded to the vicinity of Seabeck in June, with Ensign J. N. Jordan, U. S. N., in charge. Lieut. Charles T. Forse, U. S. N., when the new appropriation became available for his party expenses, assumed charge of the party.

Before passing to other topics, I desire to call your attention to the report of Lieutenant-Commander Nichols, U. S. N., on a rough plane-table used on board the steamer Hassler, for making a hydrographic reconnaissance. I have appended to this report a sketch and description made by Ensign J. H. Fillmore, U. S. N., who devised the apparatus.

I would remark also, with reference to the water signal, devised by Lieutenant Hanus, and described on page 34 of the Annual Report of the Superintendent for 1883, that further experience causes it to be commended for economy of construction and ease of placing in position. Care should be taken, however, to make the signal perfectly firm by wedging the heel, as signals of this kind need to have the heels firmly wedged to withstand the heaviest gales.

I append a list of naval officers attached to the Survey during the past fiscal year, showing the date of assignment and detachment of each officer, together with a table giving the names of vessels, their tonnage, &c., in the Coast Survey service during the same period. Also tabular statements showing the actual numbers of officers and of men attached to the several vessels in service at different periods during the fiscal year.

REPAIRS OF VESSELS.

The reduced appropriation of $27,000, smaller than that of any year since the war, has made it extremely difficult to fulfill any but the most essential requirements in repairing the vessels of the Survey.

As mentioned in my last annual report, the steam vessels which were added to the organization at about the same time, a few years after the war, have almost exceeded the limit of profitable repairs, particularly to their boilers. It is impossible to renew the boilers of all these vessels out of the available appropriation, even if there were no other calls for the money. The steamer Blake seemed to be most in need of them, and was selected as the one to be so equipped this year. A contract was made with William L. Pettit, of Baltimore, Md., in December, 1883, he being the lowest bidder of several firms, for the construction of two boilers, planned under my direction by Passed Assistant Engineer G. H. Kearny, U. S. N., the engineer officer of the vessel. Experience has developed the fact that for the Survey the cylindrical type of boiler affords generally the most beneficial results, and was the form adopted for the Blake.

The steamers Endeavor and Arago, which were fitted a short time since with this class of boiler, constructed very satisfactorily by the same contractor, proved themselves better steamers. An increase of from 10 to 15 per cent. was made in their speed, on no greater, if as great, a consumption of coal.

In order to get two boilers in the Blake in the limited space occupied by the old ones it became necessary to modify the type somewhat by putting flattened surfaces in the side for a space of nine inches, thus giving them an elliptical shape and gaining the necessary height to give the proper grate and heating surfaces. It is a source of regret that the boilers have been delayed in construction beyond the contemplated time allowed in the contract, but it is due the contractor to state that much of the delay was caused by circumstances over which he had no control. While this work was going on, occasion was taken to line up the main shaft of the engine, dock

the vessel, clean and repair her bottom, put in new brasses, and other incidentals, at a total expenditure of about $5,528.

The boiler of the steamer Bache, like those of the Blake, on her return North at the commencement of the year owing to age (about twelve years), was found to have passed beyond economical repairs. Yet the state of the appropriations made it necessary to again resort to the "patch" system to tide her over another year.

This was attended with some risk, and the weakness of the single boiler, with which she is fitted, was so strongly developed during the survey on the west coast of Florida, that I questioned whether it would not be advisable to recommend to you that the vessel be retained at Key West until a new boiler could be sent to her. This would have been attended with greatly increased expense, and Lieutenant Mansfield, her commanding officer, decided to attempt the passage north during the pleasant weather of the month of June. He accomplished it, very much to the relief of all concerned. It now becomes a matter of absolute necessity to construct a new boiler before she again goes into active service. Her total expenses for miscellaneous repairs were about $1,325.32.

The steamer Gedney made the passage to the coast of Texas, with some needed repairs left undone, owing to lack of funds, and the survey suffered in consequence by the increased amount of coal consumed. It now becomes imperative that her broken propeller be replaced, shaft lined up, &c. Her necessary repairs amounted to about $241.69 for year.

Having submitted a special estimate for new boilers for the steamer Hassler (which was included in the appropriation passed by Congress for this year), as little was done to this vessel as was consistent with safety and as would enable the party on board to execute a season's work nearer repairing facilities than when at work in Alaskan waters, where she was previously employed. Plans for new boilers are in course of preparation, and while being put in other important work will be executed. The most important item of sheathing her with wood (referred to in my last report) will have to be left for some future time.

The steamer McArthur's repairs have been comparatively slight during the year, but it is expected that age will soon have made extensive repairs to the boiler necessary. Her commanding officer has persistently urged that she be fitted with a steam windlass, not only as a measure of economy in time in getting under way, but as a matter of safety. During the year she has parted her chains twice, leaving the vessel, in one case particularly, in a very precarious position, a report of which, from Lieutenant Taussig, was submitted to you. This leads to the conclusion that her commander's reasons for urging the steam machinery are well founded, and I shall submit an estimate for accomplishing this desirable object.

The experience derived from the steam windlasses put in the Bache, Blake, and Hassler during the past four years has been very satisfactory, and I am led to hope for better results from this vessel after she has been fitted with a new windlass of the same type. The McArthur's last year's repairs amounted to $910.80.

The steamer Endeavor has had comparatively little work done to her hull, but her deck-houses have been nearly rebuilt; all the work being done by the crew, no material expense has accrued to the Survey. In the engineer's department the smoke-stack has been replaced, and the machinery generally overhauled, while the vessel was laid up at New York during the winter. This was also mainly done by the force on board the vessel, at little expense.

The steamer Barataria has been fitted with considerable new planking and guards, quite extensive repairs to her boilers, and is believed to be now in generally good condition. This, with much of the labor performed by shipped men, at a cost of $1,193.15.

The Arago has required, to meet cost of repairs, $460.24.

The schooner Eagre, as stated in my last annual report, was found to require a thorough calking of her bottom, which was made the occasion for replacing her much-needed copper. The work was done at the New York navy-yard, at lower figures than were obtained from outside estimates. Her bottom, as might be expected from her history, was found in excellent condition, while the seams showed the necessity for calking this heavy craft, to prevent working in a sea way. Advantage was taken of her entering the dock to clean and repair the bottom of the Palinurus, thus materially lessening the cost for each; and the dock not being required for other ves-

sels at the time, they were allowed to remain out of water for a period of about three weeks, with benefit to the Survey. The Eagre's total expenses for repairs were $2,098.86.

The schooner Palinurus was made ready for a season's work in Long Island Sound, including cleaning and repairing bottom sheathing, and an extension of the ward-room by shifting the cabin bulkhead, &c. This change in the quarters, it is believed, will add to the efficiency of the party and the comfort of the subofficers of the vessel, and will at the same time make the same disposition for the chief of party as exists on the other schooners of her class. Nearly all this work was done by the crew, at a total expense of $180.89.

The schooner Drift. It was found during the previous year that to permit this vessel to make an attempt to solve the problem of anchoring in deep water it would be necessary to fit her with new anchor gear.

The great resistance brought on a five and one-half inch hawser, while anchoring off the coast of Florida in three hundred and four hundred fathoms of water, produced such a strain as not only to carry away the windlass, but in the strong current of the Gulf Stream it was impossible for her to maintain a fixed position. To remedy this, a steel wire rope seven hundred and fifty fathoms long was purchased, and the vessel fitted with an iron windlass.

I regret to state that the results were only partially successful. After a slight break down in starting out the gear was found to stand, but the strain on the vessel was such as to cause serious apprehensions for her safety. Furthermore, the great length of time required in getting the anchor, with ordinary hand power, in four hundred fathoms of water, caused the vessel to get into positions of danger when occupying stations near the shore. It is recommended that the next observations be tried in the steamer Blake, where, with her steam power, I anticipate successful results. The Drift's repairs have amounted to $1,098.74.

The schooner Yukon has had sails and rigging refitted and hull and decks calked, being prepared only for quarters for a topographical party in Puget Sound. Cost, $1,163.84.

The barge Beauty was hauled out of water at Maysville, N. J., in the summer of 1881, and in attempting to repair her in May, 1883, she was found to be so rotten that it was impossible to move her. To maintain the "complement of vessels" a new barge was built and sent to replace her at a cost of $1,575.10.

The sloop Steadfast was fitted for her last season's service in Indian River and Lake Worth, in Florida, at a cost of $75.79. She being of no further use to the Survey, and it being impossible to remove her worn-out hulk from the mud banks on which she had grounded, she was stripped of all her equipments, left where she rested, and her name erased from the list of vessels.

The schooner Brisk and steamer Fathomer, as mentioned in my last report, were beyond repairs, and by your direction, being advertised for sale, were sold to the highest bidders. The Fathomer to Mr. S. Bensinger, of Washington, D. C., for the sum of $207.50, and the Brisk to Messrs. Woodward, Wight & Co., of New Orleans, La., for $210.

The schooner Scoresby was repaired for service during the summer of 1883 at a cost of $30.68.

The schooner Earnest, likewise commissioned, as well as refitted out in the spring of 1884, at a cost for repairs of $207.11.

The schooner Ready, under the same conditions as the Earnest, at a cost for repairs of $511.40.

The steamer Hitchcock, schooners G. M. Bache and Research, and sloop Kincheloe were the only vessels on the list not used at some time during the year.

One steam launch was purchased to replace the steam launch attached to the Gedney, which was found to be entirely worn out, at a cost of $2,750. In addition, the several steam launches called for an expenditure of $1,371.82, to keep them in order.

OFFICE-WORK.

The routine duties of the office have been carried on by the very able assistants, Lieut. J. E. Pillsbury, U. S. N., in charge of the chart corrections, &c., up to January 29, 1884, and after that date by Lieut. Jefferson F. Moser, U. S. N.

The special fitness of Lieutenant Pillsbury, with his long experience in the handling of charts,

led me to recommend to you that he be ordered to take charge of the publication of the Coast Pilot of the southern coast, from Cape Henry southward.

Entering upon this new work with his usual zeal, he verified the courses and distances with the schooner Ready on the outside coast of Virginia and North Carolina, and with the steamer Arago those for the sounds of North Carolina. Completing this duty, he returned to the office the last of January to prepare his manuscript for the printer, which was ready by April 12. He then took charge of the steamer Arago, and proceeded with his party on board that vessel, making examinations of the coast and inland waters adjoining the coast as far south as Savannah, Ga., returning in June.

The work under his charge has been pushed with the rapidity which its importance required, and it is recommended, as there is a general demand for a suitable publication relating to our southern coast, this manuscript be given preference in printing over all but the most important office publications.

It is a matter for congratulation that the Navy Department should have detailed an officer of Lieutenant Moser's well-known standing as a hydrographer for another tour of duty in the Survey, and with these two officers left in charge of the office it gave me the opportunity to devote most of my attention to the important work of the year, the construction of the steamer Carlile P. Patterson.

The draughtsmen of the office, Messrs. E. Willenbücher, W. C. Willenbücher, and F. C. Donn, have efficiently carried on their various duties. A synopsis from the records of the hydrographic sheets plotted by them I present below, and a detailed statement of their work is made a matter of record in this office:

Names.	Number of—				
	Volumes.	Angles.	Soundings.	Miles.	Deep-sea soundings.
E. Willenbücher	97	24,796	154,298	6,931	2,866
W. C. Willenbücher	72	21,160	135,274	1,897	......
F. C. Donn	64	14,387	71,853	3,137	......
	233	60,343	361,425	11,965	2,866

In addition to his extensive clerical duties, Mr. E. H. Wyvill has assisted very materially in making tracings and preparation of data properly belonging to the draughtsmen, but which, owing to the accumulation of records, the force was unable to take in hand.

CONSTRUCTION OF VESSELS.

In anticipation of Congress taking some action in the appropriation bill for the fiscal year 1883 for the "construction of a steamship for the survey of the Pacific coast and sounds," plans and specifications were prepared under my direction after the general type of vessels which had given such good results in the Survey.

Through the courtesy of Naval Constructor S. H. Pook, at the navy-yard, Washington, D. C., Mr. Frothingham, the draughtsman of his department, prepared the drawings and model with much credit to himself, and otherwise gave me valuable assistance.

The action of Congress being favorable to the project, bids were asked for as prescribed by law, and on June 1, 1883, were opened, as per advertisement, and the following records were made:

Bidders.	Location.	Bids.
James D. Leary	Brooklyn, N. Y.	$79,400
Wm. E. Woodall & Co	Baltimore, Md	79,500
Slater & Reid	New York, N. Y.	91,000
Goss & Ward	Alexandria, Va.	90,000
Chas. Reeder & Son.	Baltimore, Md	96,875
Pusey Jones Co.	Wilmington, Del	114,000
Union Iron Works	San Francisco, Cal.	121,000

Mr. James D. Leary being the lowest responsible bidder, and his facilities for building such a vessel as was required proving satisfactory, a contract for her construction was made with him by you on July 1, 1883.

Your directions appointing me the inspector on the part of the Government, and assigning Lieut. R. Clover, U. S. N., and Passed Assistant Engineer H. N. Stevenson, U. S. N., as my assistants, were received, and under them the following assignments made: Lieutenant Clover, who had been associated with me in the preparation of the data from the inception of the project of building a vessel especially adapted to the survey of Alaskan waters by your predecessor, Mr. Carlile P. Patterson, was stationed at New York, taking the immediate charge of the work, and under his constant watchfulness nearly every timber and bolt that went into the construction of the vessel received careful inspection. It is believed that the scheme of having the officer on whom was to rest the responsibility of a long voyage to the Pacific, and afterwards possible trying circumstances on the coast of Alaska, associated in the construction of the vessel has been fraught with good results to the Government as well as to himself as her future commander. That he acquitted himself with credit you well know. Mr. Stevenson was located at Philadelphia, Pa., where the steamer's machinery was being made by Messrs. Neafie & Levy. This officer, as mentioned in my last report, had also been associated with me in planning the machinery, and, as her future engineer officer, was deeply interested in the careful construction of the motive power of the vessel.

This arrangement of the duties left me to proceed from point to point where I was needed to decide questions of construction, and to see that all workmanship and material was first class and satisfactory to the inspector.

As I propose to submit to you a complete report of the construction, equipment, and the trials of the vessel, I shall only mention in passing that her keel was laid August 1, 1883, and she was launched January 15, 1884. A satisfactory trial was made down New York Bay to Sandy Hook light-ship May 5, 1884, and later a sea voyage covering over forty-eight hours, ending at Washington, D. C., June 5. As she was not completely fitted for her passage to the Pacific coast at the date on which this report closes, I prefer to make a full report after all the data concerning her trials are received.

Very respectfully submitted.

C. M. CHESTER,
Commander, United States Navy,
Hydrographic Inspector U. S. Coast and Geodetic Survey.

Prof. J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

NAVAL OFFICERS ON DUTY AND VESSELS IN SERVICE.

The following statements give in tabular form the names and number of naval officers employed in the service of the Coast and Geodetic Survey during the fiscal year, and the names of vessels belonging to the Coast Survey:

Officers of the Navy on Coast and Geodetic Survey service during the fiscal year ending June 30, 1884

Name.	Date attached.	Remarks.
COMMANDERS.		
C. M. Chester	Oct. 2, 1877	Still in service.
LIEUTENANT-COMMANDERS.		
W. H. Brownson	Aug. 11, 1881	Do.
H. E. Nichols	Jan. 22, 1879	Do.
A. S. Snow	Aug. 1, 1883	Do.
LIEUTENANTS.		
J. T. Sullivan	Nov. 21, 1882	Do.
H. B. Mansfield	Feb. 28, 1881	Do.
LIEUTENANTS—Cont'd.		
E. D. F. Heald	Nov. 23, 1882	Still in service.
Richardson Clover	July 26, 1881	Do.
E. D. Taussig	Apr. 30, 1883	Do.
J. E. Pillsbury	July 13, 1882	Do.
Jeff. F. Moser	Jan. 29, 1884	Do.
A. V. Wadhams	Apr. 18, 1883	Detached January 30, 1884.
G. Blocklinger	Jan. 30, 1883	Still in service.
T. Dix Bolles	Apr. 5, 1881	Detached January 31, 1884.
E. M. Hughes	June 22, 1880	Detached October 1, 1883.
J. D. Keeler	June 29, 1883	Detached April 15, 1884.
F. M. Crosby	Nov. 17, 1882	Detached March 25, 1884.

Officers of the Navy on Coast and Geodetic Survey service, &c.—Continued.

Name.	Date attached.	Remarks.	Name.	Date attached.	Remarks.
LIEUTENANTS—Cont'd.			ENSIGNS—Continued.		
J. B. Milton	Sept. 6, 1882	Detached January 22, 1884.	C. W. Jungen	Aug. 25, 1883	Still in service.
G. C. Hanus	Mar. 20, 1883	Still in service.	R. P. Schwerin	May 3, 1883	Do.
W. P. Elliott	Jan. 25, 1879	Detached August 31, 1883.	D. P. Menefee	July 28, 1883	Do.
F. H. Lefavor	Sept. 6, 1882	Still in service.	F. W. Kellogg	Aug. 23, 1882	Do.
J. C. Fremont	May 21, 1881	Do.	Harry Phelps	June 30, 1882	Do.
F. A. Wilner	Dec. 14, 1880	Detached September 30, 1883.	William Truxton	July 3, 1882	Do.
Lucien Flynn	May 7, 1881	Detached November 1, 1883.	E. Simpson, jr	Oct. 21, 1882	Do.
W. G. Cutler	Mar. 29, 1883	Still in service.	J. H. Watters	July 7, 1883	Do.
C. McR. Winslow	Aug. 16, 1881	Do.	E. F. Leiper	Apr. 26, 1883	Do.
David Daniels	Apr. 21, 1882	Detached November 26, 1883.	M. C. Gorgas	Oct. 26, 1882	Do.
ENSIGNS.			L. S. Van Duzer	Aug. 22, 1882	Detached December 31, 1883.
			F. R. Brainard	July 20, 1883	Still in service.
W. B. Caperton	Nov. 11, 1880	Detached November 30, 1883.	T. G. Dewey	June 18, 1883	Do.
E. M. Katz	Nov. 22, 1881	Detached August 9, 1883.	G. M. Brown	Dec. 26, 1882	Detached July 5, 1883.
J. T. Newton	Aug. 19, 1882	Detached December 26, 1883.	G. R. French	May 4, 1883	Still in service.
E. N. Fisher	Feb. 10, 1882	Detached January 19, 1884.	PASSED ASSISTANT SURGEONS.		
T. D. Griffin	May 2, 1883	Still in service.			
F. H. Sherman	Oct. 31, 1882	Do.			
H. M. Weitzel	Feb. 10, 1882	Detached November 19, 1883.	W. S. Dixon	Apr. 20, 1884	Do.
O. G. Dodge	May 10, 1881	Detached November 30, 1883.	T. H. Streets	Mar. 19, 1884	Do.
J. M. Orchard	Feb. 10, 1882	Still in service.	E. Y. Derr	Sept. 7, 1881	Do.
J. N. Jordan	Jan. 25, 1881	Do.	R. H. McCarty	Apr. 8, 1881	Detached April 1, 1884.
J. P. Parker	Mar. 5, 1883	Do.	S. W. Battle	Nov. 17, 1881	Detached February 1, 1884.
H. C. Wakenshaw	June 23, 1882	Detached July 28, 1883.	H. C. Beyer	May 31, 1882	Detached June 2, 1884.
A. F. Fechteler	June 24, 1882	Still in service.	F. C. Dale	June 6, 1883	Detached December 31, 1883.
T. M. Brumby	Dec. 21, 1882	Do.	W. H. Rush	June 3, 1884	Still in service.
Alfred Jeffries	July 17, 1882	Do.	ASSISTANT SURGEONS.		
W. V. Bronaugh	Aug. 12, 1881	Do.			
F. M. Bostwick	Sept. 28, 1881	Do.	H. B. Fitts	Jan. 27, 1884	Do.
A. L. Hall	May 1, 1883	Do.	PASSED ASSISTANT PAYMASTERS.		
P. J. Werlick	Mar. 15, 1884	Still in service.			
J. H. Fillmore	Jan. 24, 1883	Detached November 22, 1883.	J. R. Stanton	Nov. 1, 1883	Do.
C. S. McClain	Apr. 14, 1882	Detached November 19, 1883.	PASSED ASSISTANT ENGINEERS.		
Harry S. Knapp	July 6, 1882	Detached November 30, 1883.			
W. L. Burdick	Mar. 31, 1884	Still in service.			
P. B. Bibb	Nov. 30, 1882	Do.	H. Main	May 29, 1883	Do.
W. C. Canfield	Sept. 26, 1882	Do.	H. N. Stevenson	Mar. 10, 1883	Do.
W. P. White	Feb. 10, 1883	Do.	G. H. Kearney	Oct. 5, 1881	Do.
J. E. Craven	Nov. 28, 1883	Do.	R. W. Galt	Nov. 26, 1879	Do.
J. H. Hetherington	June 19, 1883	Do.	E. T. Warburton	Feb. 24, 1883	Do.
C. C. Marsh	May 3, 1884	Do.	R. I. Reid	June 9, 1882	Do.

RECAPITULATION.

Commanders	1
Lieutenant-commanders	3
Lieutenants	23
Ensigns	44
Passed assistant surgeons	8
Assistant surgeons	1
Passed assistant paymasters	1
Past assistant engineers	6
Total	87

NOTE.—An analysis of the preceding tabular statement shows that of the 87 naval officers above named, 14 were not ordered to duty on the survey till after the beginning of the fiscal year; 26 were detached during the fiscal year, and 61 were in service at its close.

Names of vessels, their tonnage, &c., in the service of the Coast and Geodetic Survey during the fiscal year ending June 30, 1884.

No.	Name of vessel.	Tonnage	Complement of— Officers.	Men.
1	Steamer C. P. Patterson	453	9	36
2	Steamer Hassler	243	9	34
3	Steamer Blake	218	8	36
4	Steamer Bache	186	7	33
5	Steamer Gedney	133	7	29
6	Steamer McArthur	112	7	29
7	Steamer Endeavor	105	5	17
8	Steamer Hitchcock (laid up)	83		
9	Steamer Fathomer (laid up)	50		
10	Steamer Barataria	50	1	15
11	Steamer Arago	38	3	15
1	Schooner Eagre	202	4	18
2	Schooner Drift	87	4	14
3	Schooner Earnest	80	2	12
4	Schooner Ready	80	3	14
5	Schooner Yukon (civilian party)	78		
6	Schooner Research (laid up)	76		
7	Schooner Palinurus	76	3	14
8	Schooner Silliman	72	3	14
9	Schooner Scoresby	72	2	12
10	Schooner G. M. Bache (laid up)	46		
11	Schooner Brisk (laid up)	38		
12	Schooner Quick (civilian party)	38		
1	Sloop Steadfast	39	1	12
2	Sloop Kincheloe (civilian party)	30		
1	Barge Beauty (civilian party)	28		

RECAPITULATION.

Whole number of vessels:	
Steamers	11
Schooners	12
Sloops	2
Barge	1
Total	26
Number of vessels in active service	21

This complement does not represent the actual number of officers or of men in the Survey during the year, owing to the fact that some vessels were employed only a part of the time.

Average number of officers for the year 66
Average number of men for the year 271

See tabular statements appended showing actual number of officers attached to the several vessels in service and number of officers on other duty at different periods during the fiscal year; also the number of men actually in service at the end of each quarter of the fiscal year, with the names of the vessels in which they were serving:

Number of naval officers attached to Coast and Geodetic Survey vessels for fiscal year ending June 30, 1884.

Name of vessel.	September 30, 1883.	March 31, 1884.	Name of vessel.	September 30, 1883.	March 31, 1884.
Steamer Blake	8	8	Schooner Palinurus	3	1
Steamer Bache	7	7	Schooner Drift	3	4
Steamer Gedney	7	7	Schooner Silliman	3	3
Steamer Endeavor	3	2	Schooner Ready	3	1
Steamer Arago	4	3	Schooner Scoresby	2	2
Steamer Hitchcock	1	....	Schooner Earnest	2	1
Steamer Barataria	....	1	Sloop Steadfast	....	1
Steamer Hassler	8	8	Coast Survey Office	3	4
Steamer McArthur	7	6	Special duty	2	2
Schooner Eagre	4	1	Total	70	62

Average number, 66.

Number of men attached to Coast and Geodetic Survey vessels for fiscal year ending June 30, 1884.

Name of vessel.	For quarter ending— September 30, 1883.	December 31, 1883.	March 31, 1884.	June 30, 1884.
Steamer Blake	36	25	30	37
Steamer Bache	33	30	33	22
Steamer Gedney	26	22	27	27
Steamer Endeavor	19	7	9	19
Steamer Arago	15	12	14	2
Steamer Hitchcock	2	2	2	2
Steamer Barataria	2	13	15	2
Steamer Hassler	32	28	29	32
Steamer McArthur	28	28	29	28
Steamer Patterson	....	....	....	34
Schooner Eagre	19	4	6	19
Schooner Palinurus	15	7	6	16
Schooner Drift	14	14	15	15
Schooner Silliman	15	5	5	1
Schooner Ready	16	5	4	7
Schooner Scoresby	11	3	4	1
Schooner Earnest	12	7	6	16
Sloop Steadfast	2	13	13	....
Vessels laid up	10	9	8	8
Total	307	234	255	288

Average number, 271 men.

DESCRIPTION OF A METHOD OF SKETCHING IN SHORE-LINE, WHEN MAKING PRELIMINARY OR RUNNING SURVEYS, AVOIDING THE NECESSITY OF ESTIMATING DISTANCES OR OF DEPENDING ON THE EYE TO GET THE CONFIGURATION OF THE SHORE-LINE.

By Ensign J. H. FILLMORE, U. S. N., *attached to the party of Lieut. Commander H. E. Nichols, U. S. N., Assistant, Coast and Geodetic Survey.*

The instrument is a modification of the plane table, and consists of a plane table or drawing board, mounted on a tripod, and two rulers. One ruler is attached to the edge of the board so as to move freely in the direction of its length across the board, with room underneath it for the sketching paper. This ruler is pointed at one end, and graduated from that end as zero. The other is an ordinary straight-edge ruler, with sights at the ends.

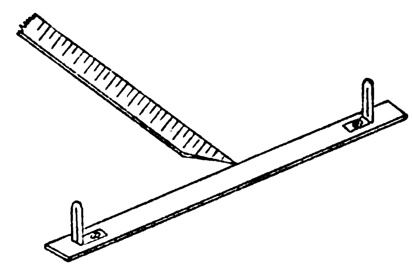


Fig. 1.

To sketch in a shore-line, the ship or boat is to run along the shore at as uniform a speed as possible, and with as few courses as is consistent with keeping at a convenient distance from the shore. The distance from the shore being determined by the minuteness of the details which it is desired to see and record, the board is mounted on the deck so as to command as much of the horizon as possible. The pointed ruler is to be parallel to the ship's track. Ordinarily this will be parallel to the keel; but if the ship is making drift or steering a range, then it is parallel to the actual course and not to the keel. A line drawn along the edge of this ruler will be the ship's track on the paper. The graduations of this ruler are in time, so that if at any instant the point of the ruler is at the ship's position on the paper, then at any other time, say three minutes later, the point may be moved to the ship's new position by moving the ruler ahead three minutes, or three divisions of its graduation. Thus, at any instant when the ship is moving along the shore, the point of this ruler may be put at her position on the paper by moving it forward the proper number of time graduations, a watch being before the draughtsman for that purpose. Now, to put in the shore, take bearings of points on the shore with the sighting ruler, having its edge against the

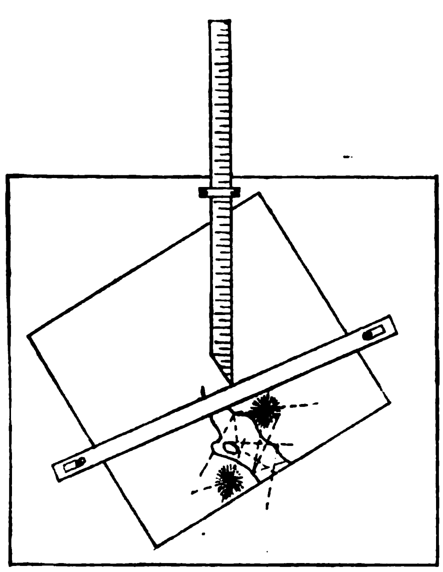


Fig. 2.

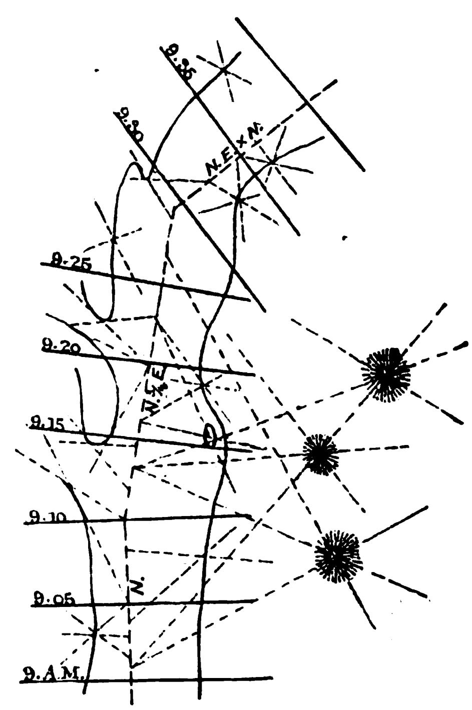


Fig. 3.

point of the other ruler, the latter point being at the proper time or place in the ship's track, and draw these bearings on the paper.

As soon as more than one bearing is taken of the same point on shore from different places or times in the ship's track that point is fixed by the intersection.

It is in fact a triangulation on the point, with the ship's track as a base line.

By selecting points as they come in sight on the bow, taking a bearing then, one when it is nearly abeam, and another when well abaft the beam, good angles can always be made. It is not necessary, of course, to wait for even minutes or divisions of the ruler, but at any instant when a bearing is wanted move the ruler to the proper place, estimating the fractions of minutes between the divisions. The whole shore-line is thus put in by cutting in points as the ship goes by them.

To change the course, move the paper through the angle of change about the point of the ruler, occupying the ship's position at the time of turning. The edge of the pointed ruler will then be on the ship's new track.

This angle may be laid off with a protractor, or, if the ship is to head for a visible point, the new track may be drawn with the sighting ruler just before turning, and the paper then turned until the edge of the pointed ruler is along the new track.

When the sketch is between known points, as these are passed they are to be cut in the same as other points of the shore-line. Or the ship may be cut in by the angles on signals or known objects. Then, when plotting the work, the ship's track is laid down from one known point towards the other, and the other known point is plotted from the sketch. Then, all known errors having been eliminated, the difference between the plotted position of the point and its proper position is an error, which must be distributed throughout the ship's track. This may be done as shown in Figure 4:

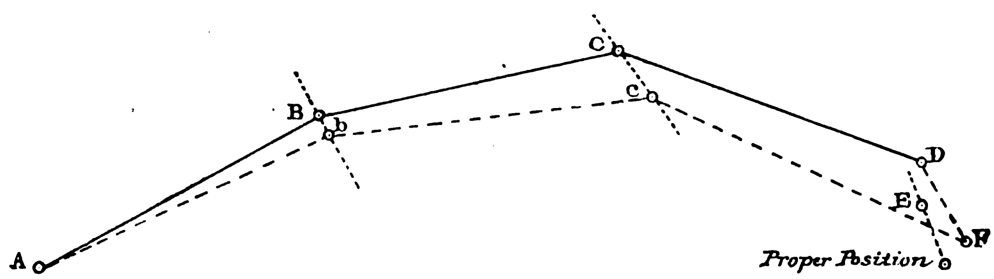


Fig. 4.

The full line represents the plotted track and the broken line the corrected one, the dotted lines are drawn through the points where the course was changed and parallel to the line through the plotted and true positions of the second known point. The distances B*b* C*c*, &c., are laid off of such lengths that B*b* : A B = E F : A D and C*c* : A C = E F : A D, &c., thus proportioning the errors throughout the track. When there is only one known point, a run may be made along the shore-line to be put in and back to the same point; then plotting the whole course, the error in the final position of the point can be distributed in the same manner.

If the steering is bad or difficult, the draughtsman can, by noting the bearing of some object directly ahead, know when the ship is exactly on her course, and by only taking bearings then, can make the method nearly independent of bad steering. If when this precaution is taken the bearings of points do not intersect well, then the pointed ruler is not parallel to the ship's actual course. This should be corrected by turning the table until the pointed ruler is in the right direction, and when the change in drift is equivalent to a change in course, the paper should also be turned in the opposite direction the same as for a change in the course; a note being made of the course made good.

The ship should be carefully logged and a record kept of the courses and distances made good, to be used in plotting the work.

If in using the rulers the pointed one be found to be unsteady, or the end not to remain close to the paper, a paper-weight may be used to hold it in place when taking a bearing.

APPENDIX No. 6.

TABLES FOR THE PROJECTION OF MAPS, BASED UPON A POLYCONIC DEVELOPMENT OF THE CLARKE SPHEROID, AND COMPUTED FROM THE EQUATOR TO THE POLE.

The tables here given for the projection of maps upon a polyconic development are based upon our knowledge of the dimensions and figure of the earth as derived by Colonel Clarke, R. E., in 1866. They are intended to supersede all former projection tables published by the Survey, and for greater usefulness have been extended to include the entire quadrant from the equator to the pole.

Up to the year 1880, the elements of the earth's magnitude and figure derived from Bessel had been in use for the representation of all geographical positions, and upon them were based the projection tables published in the Coast Survey Reports for 1853, 1856, 1859, and 1865. These elements were: Equatorial semi-axis $a = 6377397.2$ meters; polar semi-axis $b = 6356079.0$ meters

$$a : b :: 299.153 : 298.153$$

The projection tables which appeared in the Report for 1853 (Appendix 39) were the earliest published by the Coast Survey, and were accompanied by an exposition of the method and its special adaptations prepared by E. B. Hunt, U. S. A., Assistant in the Coast Survey. In the Report for 1856 (Appendix 58) were published "Tables for projecting maps of large extent, arranged by Assistant J. E. Hilgard." These tables were afterward extended by Mr. Hilgard and republished in Appendix 33, Report for 1859; a further extension, making the tables applicable to the projection of a map of North America, appeared in the Report for 1865, Appendix 20.

In the Report of the Coast and Geodetic Survey for 1880 (Appendix No. 15) Assistant C. A. Schott gives in a very compact form a statement of much that is of practical importance bearing upon the subject of different projections, comparing them with the polyconic projection for relative value and precision.

In 1882 was published by the Survey a "Treatise on Projections, by Thomas Craig, Ph.D.," which discusses and develops the mathematical principles upon which all the various forms of projections depend.

Additional and more precise measurements having been made in many parts of the earth, notably in India, since the publication of the Bessel elements in 1837 and 1841, they were compared and combined by Col. A. R. Clarke, R. E. at the British Ordnance Survey Office, and were published in the volume, "Comparisons of the Standards of Length, &c., made at the Ordnance Survey Office, Southampton, 1866."

He gives for the two semi-axes a resulting value:

$$a = 6\ 378\ 206.4 \text{ meters.} \qquad b = 6\ 356\ 583.8 \text{ meters.}$$

$$a : b :: 294.98 : 293.98$$

developing a spheroid of slightly larger dimensions and greater eccentricity.

So nearly have these elements been found to represent the curvature and magnitude resulting from the trigonometrical work of the Coast and Geodetic Survey, that no subsequent change in

the general dimensions would so far affect the territory of the United States as to make it useful to seek a better general surface of projection for this country.

In the Report for 1875 (Appendix 19) tables were given for converting certain co-efficients and arcs from the Bessel to the Clarke spheroid of 1866, and in February, 1880, the latter spheroid was formally adopted for use on the survey. In Appendix No. 7 to the present volume is given a new edition of the tables for the computation of geodetic latitudes, longitudes, and azimuths.

The formulæ used in the following tables are the same as those printed in the projection tables of 1853 and 1856, varying in the numerical values only to suit the dimensions of the new spheroid.

For lengths of degrees of the meridian (D_m) and parallel (D_p) they now become

$$\text{(I.)}\quad D_m = 111\,132^{m}.09 - 566^{m}.05 \cos 2\varphi + 1^{m}.20 \cos 4\varphi - 0^{m}.003 \cos 6\varphi$$

$$\text{(II.)}\quad D_p = 111\,415^{m}.10 \cos\varphi - 94^{m}.54 \cos 3\varphi + 0^{m}.12 \cos 5\varphi,$$ neglecting smaller terms,

where $\varphi =$ the latitude. We have also the square of the eccentricity $e^2 = 0.006768658$

$$\text{where } e^2 = \frac{a^2 - b^2}{a^2}$$

(III.) Normal produced to minor axis: $N = \dfrac{a}{(1 - e^2 \sin^2 \varphi)^{\frac{1}{2}}}$

(IV.) Radius of curvature in the meridian: $R_m = N^3 \dfrac{1-e^2}{a^2}$

(V.) Radius of the parallel: $R_p = N \cos \varphi$

(VI.) Radius of the developed parallel or side of the tangent cone: $r = N \cot \varphi$

(VIII.) If n be any arc of the parallel to be developed, and θ the angle which it subtends at the vertex of the cone when developed:

$$\theta = n \sin \varphi$$

(VIII.) For projecting from the middle meridian the points of intersection of the meridians and parallels we have, using rectangular co-ordinates X and Y,

$$X = r \sin \theta; \quad Y = 2r \sin^2 \tfrac{1}{2}\theta$$

ARRANGEMENT AND EXPLANATION OF THE TABLES.

The unit of linear measure of the Coast and Geodetic Survey is the meter, and the relation of the meter to the yard now in use upon the work is that derived by Captain Clarke, R. E., in 1866, from comparisons of new British standards, with several well accredited copies of the meter. In a paper published as Appendix No. 22 to the Coast Survey Report for 1876, and in an amplified edition of this paper which appeared as Appendix No. 12 to the Report for 1877, Assistant J. E. Hilgard has given a statement of the relation of the lawful standards of measure of the United States to those of Great Britain and France, and has presented a concise record and discussion of the observations upon which rest the relations assigned to different standards of length.

The ratio of the yard to the meter as stated by Clarke, namely: 1 meter = 1.093623 yard = 39.370432 inches, is that used in the first and second conversion tables.

Other tables are for the conversion of meters into statute and nautical miles. The length of a nautical mile in use upon the survey, upon which these tables are based, namely, 1 nautical mile = 1853.248 meters = 6080.27 feet is that given by J. E. Hilgard, Superintendent, in his paper on the subject published in Appendix No. 12, Report for 1881.

On pages 140 and 141 are table of lengths of degrees of the parallel, for every half degree of latitude, from the equator to the pole, and a table of lengths of each degree of the meridian.

Then follow the Projection Tables, so arranged that all values expressed in them from any degree of latitude to the next greater degree shall be before the reader without the necessity of turning a page.

On the left of each double page are given the values of arcs of the parallel for every minute of latitude and from 1″ to 5′ of longitude.

On the right of each double page are the corresponding values of all meridional arcs from 1″ to 1° so arranged that intermediate values may be taken out at will.

If it is desired to know the number of meters between latitude 40° 05′ 25″ and 40° 45′ 45″ we turn to the page for Lat. 40 of the tables and find in column headed sum of minutes

Latitude	40° 05′	=	9252.8ᵐ
Latitude	40° 45′	=	83280.0
Arc			74027.2
Diff. of seconds =	20″	=	616.9
			74644.1 = Length of arc required.

On the same page are given the values of the co-ordinates X and Y for differences of longitude up to 30° on each side of the central meridian.

GRAPHIC CONSTRUCTION OF POLYCONIC PROJECTIONS FOR LIMITED AREAS.

Having fixed the limiting meridians and parallels and the scale, draw a meridian line as nearly through the center of the sheet as possible. Take from the tables of meridional arcs the distances from the northern limiting parallel to the center and thence to the southern limit of the projection, and lay off these distances from an assumed point in the central line near the top of the sheet. From the three points thus found draw three lines perpendicular to the central meridian entirely across the sheet, and test their precision by diagonal measures. Lay off on each of the perpendiculars both east and west of the central meridian, the tabular ordinates (X) for the latitude of the perpendicular, and for the longitudes intended to be covered between meridians upon the projection when completed. At each point (X_1) (X_2) (X_3), &c., thus found, lay off the corresponding co-ordinate (Y) parallel to the central meridian.

Through the three points (Y) at each perpendicular draw meridian lines with great care. In all projections on single sheets covering an area of moderate extent, say 200 miles square, these lines will be so nearly straight that their curvature cannot be detected in drawing the meridians.

Next divide the spaces between the points Y on each meridian into convenient equal parts of the same value as the spaces taken between the meridians. Curved lines drawn through the points thus found will represent parallels and will complete the projection.

CONVERSION TABLES.

METERS INTO YARDS.

1 meter = 1.093623 yards.

Meters.	Yards.	Meters.	Yards.	Meters.	Yards.	Meters.	Yards.	Meters.	Yards.
100 000	109 362.3								
90 000	98 426.1	9 000	9 842.61	900	984.26	90	98.426	9	9.843
80 000	87 489.8	8 000	8 748.98	800	874.90	80	87.490	8	8.749
70 000	76 553.6	7 000	7 655.36	700	765.54	70	76.554	7	7.655
60 000	65 617.4	6 000	6 561.74	600	656.17	60	65.617	6	6.562
50 000	54 681.2	5 000	5 468.12	500	546.81	50	54.681	5	5.468
40 000	43 744.9	4 000	4 374.49	400	437.45	40	43.745	4	4.374
30 000	32 808.7	3 000	3 280.87	300	328.09	30	32.809	3	3.281
20 000	21 872.5	2 000	2 187.25	200	218.72	20	21.872	2	2.187
10 000	10 936.2	1 000	1 093.62	100	109.36	10	10.936	1	1.094

YARDS INTO METERS.

1 yard = 0.914392 meter.

Yards.	Meters.	Yards.	Meters.	Yards.	Meters.	Yards.	Meters.	Yards.	Meters.
100 000	91 439.2								
90 000	82 295.3	9 000	8 229.53	900	822.95	90	82.295	9	8.230
80 000	73 151.3	8 000	7 315.13	800	731.51	80	73.151	8	7.315
70 000	64 007.4	7 000	6 400.74	700	640.07	70	64.007	7	6.401
60 000	54 863.5	6 000	5 486.35	600	548.64	60	54.864	6	5.486
50 000	45 719.6	5 000	4 571.96	500	457.20	50	45.720	5	4.572
40 000	36 575.7	4 000	3 657.57	400	365.76	40	36.576	4	3.658
30 000	27 431.8	3 000	2 743.18	300	274.32	30	27.432	3	2.743
20 000	18 287.8	2 000	1 828.78	200	182.88	20	18.288	2	1.829
10 000	9 143.9	1 000	914.39	100	91.44	10	9.144	1	0.914

CONVERSION TABLES.

METERS INTO STATUTE AND NAUTICAL MILES.

1 meter = 0.00062138 statute mile.
1 meter = 0.00053959 nautical mile.

Meters.	Statute Miles.	Nautical Miles.	Meters.	Statute Miles.	Nautical Miles.	Meters.	Statute Miles.	Nautical Miles.	Meters.	Statute Miles.	Nautical Miles.
100 000	62.138	53.959									
90 000	55.924	48.563	9 000	5.592	4.856	900	0.559	0.486	90	0.056	0.049
80 000	49.710	43.167	8 000	4.971	4.317	800	0.497	0.432	80	0.050	0.043
70 000	43.496	37.772	7 000	4.350	3.777	700	0.435	0.378	70	0.043	0.038
60 000	37.283	32.376	6 000	3.728	3.238	600	0.373	0.324	60	0.037	0.032
50 000	31.069	26.980	5 000	3.107	2.698	500	0.311	0.270	50	0.031	0.027
40 000	24.855	21.584	4 000	2.486	2.158	400	0.249	0.216	40	0.025	0.022
30 000	18.641	16.188	3 000	1.864	1.619	300	0.186	0.162	30	0.019	0.016
20 000	12.428	10.792	2 000	1.243	1.079	200	0.124	0.108	20	0.012	0.011
10 000	6.214	5.396	1 000	0.621	0.540	100	0.062	0.054	10	0.006	0.005

STATUTE AND NAUTICAL MILES INTO METERS.

1 statute mile = 1609.330 meters.
1 nautical mile = 1853.248 meters.

Miles.	Meters in Statute Miles.	Meters in Nautical Miles.	Miles.	Meters in Statute Miles.	Meters in Nautical Miles.	Miles.	Meters in Statute Miles.	Meters in Nautical Miles.	Miles.	Meters in Statute. Miles.	Meters in Nautical Miles.
100	160 933.0	185 324.8									
90	144 839.7	166 792.3	9	14 483.97	16 679.23	.9	1 448.40	1 667.92	.09	144.84	166.79
80	128 746.4	148 259.8	8	12 874.64	14 825.98	.8	1 287.46	1 482.60	.08	128.75	148.26
70	112 653.1	129 727.4	7	11 265.31	12 972.74	.7	1 126.53	1 297.27	.07	112.65	129.73
60	96 559.8	111 194.9	6	9 655.98	11 119.49	.6	965.60	1 111.95	.06	96.56	111.19
50	80 466.5	92 662.4	5	8 046.65	9 266.24	.5	804.67	926.62	.05	80.47	92.66
40	64 373.2	74 129.9	4	6 437.32	7 412.99	.4	643.73	741.30	.04	64.37	74.13
30	48 279.9	55 597.4	3	4 827.99	5 559.74	.3	482.80	555.97	.03	48.28	55.60
20	32 186.6	37 065.0	2	3 218.66	3 706.50	.2	321.87	370.65	.02	32.19	37.06
10	16 093.3	18 532.5	1	1 609.33	1 853.25	.1	160.93	185.32	.01	16.09	18.53

LENGTHS OF DEGREES OF THE PARALLEL.

Lat.	Meters.	Yards.	Statute miles.	Nautical miles.	Lat.	Meters.	Yards.	Statute miles.	Nautical miles.	Lat.	Meters.	Yards.	Statute miles.	Nautical miles.
° ′					° ′					° ′				
0 00	111 321	121 743	69.172	60.068	30 00	96 488	105 521	59.956	52.064	60 00	55 802	61 026	34.674	30.110
30	1 316	1 738	9.169	0.065	30	6 001	4 989	9.653	1.801	30	4 958	0 103	4.150	29.654
1 00	1 304	1 725	9.162	0.059	31 00	5 506	4 448	9.345	1.534	61 00	4 110	59 176	3.623	9.197
30	1 283	1 702	9.149	0.047	30	5 004	3 899	9.033	1.264	30	3 257	8 243	3.093	9.737
2 00	1 253	1 669	9.130	0.031	32 00	4 495	3 342	8.716	0.989	62 00	2 400	7 306	2.560	8.275
30	111 215	121 627	69.106	60.011	30	93 979	102 [illegible]8	58.396	50.710	30	51 540	56 365	32.025	27.811
3 00	1 169	1 577	9.078	59.986	33 00	3 455	2 205	8.071	0.428	63 00	0 675	5 419	1.488	7.344
30	1 114	1 517	9.044	9.956	30	2 925	1 625	7.741	0.142	30	49 806	4 469	0.948	6.875
4 00	1 051	1 448	9.005	9.922	34 00	2 387	1 037	7.407	49.851	64 00	8 934	3 515	0.406	6.404
30	0 980	1 370	8.960	9.884	30	1 842	100 441	7.068	9.557	30	8 057	2 556	29.862	5.931
5 00	110 900	121 283	68.911	59.840	35 00	91 290	99 837	56.725	49.259	65 00	47 177	51 594	29.315	25.456
30	0 812	1 187	8.856	9.793	30	0 731	9 226	6.378	8.958	30	6 294	0 628	8.766	4.979
6 00	0 715	1 081	8.795	9.741	36 00	0 166	8 608	6.027	8.653	66 00	5 407	49 658	8.215	4.501
30	0 610	0 966	8.730	9.684	30	89 593	7 981	5.671	8.344	30	4 516	8 684	7.661	4.021
7 00	0 497	0 841	8.660	9.622	37 00	9 014	7 348	5.311	8.031	67 00	3 622	7 706	7.106	3.538
30	110 375	120 709	68.585	59.557	30	88 428	96 707	54.947	47.715	30	42 724	46 724	26.548	23.053
8 00	0 245	0 566	8.504	9.487	38 00	7 835	6 058	4.579	7.395	68 00	1 823	5 739	5.988	2.567
30	0 106	0 414	8.418	9.412	30	7 235	5 402	4.206	7.071	30	0 919	4 750	5.426	2.079
9 00	109 959	0 254	8.326	9.333	39 00	6 629	4 739	3.829	6.744	69 00	0 012	3 758	4.862	1.590
30	9 804	120 084	8.230	9.249	30	6 016	4 069	3.448	6.413	30	39 102	2 763	4.297	1.099
10 00	109 641	119 906	68.129	59.161	40 00	85 396	93 391	53.063	46.079	70 00	38 188	41 763	23.729	20.606
30	9 469	9 718	8.022	9.068	30	4 770	2 706	2.674	5.741	30	7 272	0 761	3.160	0.112
11 00	9 289	9 521	7.910	8.971	41 00	4 137	2 014	2.281	5.399	71 00	6 353	39 756	2.589	19.616
30	9 101	9 315	7.793	8.870	30	3 498	1 315	1.884	5.054	30	5 431	8 748	2.016	9.118
12 00	8 904	9 100	7.670	8.764	42 00	2 853	90 610	1.483	4.706	72 00	4 506	7 737	1.441	8.619
30	108 699	118 876	67.543	58.653	30	82 201	89 897	51.078	44.355	30	33 578	36 722	20.865	18.119
13 00	8 486	8 643	7.410	8.538	43 00	1 543	9 177	0.669	4.000	73 00	2 648	5 705	0.287	7.617
30	8 265	8 401	7.273	8.419	30	0 879	8 451	0.257	3.642	30	1 716	4 685	19.708	7.114
14 00	8 036	8 150	7.131	8.295	44 00	0 208	7 717	49.840	3.280	74 00	0 781	3 663	9.127	6.609
30	7 798	7 890	6.983	8.167	30	79 532	6 978	9.419	2.915	30	29 843	2 637	8.544	6.103
15 00	107 553	117 621	66.830	58.034	45 00	78 849	86 231	48.995	42.546	75 00	28 903	31 609	17.960	15.596
30	7 299	7 344	6.672	7.897	30	8 160	5 478	8.567	2.175	30	7 961	0 579	7.374	5.088
16 00	7 036	7 057	6.510	7.756	46 00	7 466	4 719	8.136	1.801	76 00	7 017	29 546	6.788	4.578
30	6 766	6 762	6.342	7.610	30	6 765	3 952	7.700	1.423	30	6 071	8 512	6.200	4.067
17 00	6 487	6 457	6.169	7.459	47 00	6 058	3 179	7.261	1.041	77 00	5 123	7 475	5.611	3.556
30	106 201	116 144	65.991	57.305	30	75 346	82 400	46.818	40.656	30	24 172	26 435	15.020	13.043
18 00	5 906	5 821	5.808	7.146	48 00	4 628	1 615	6.372	0.268	78 00	3 220	5 394	4.428	2.529
30	5 604	5 491	5.620	6.983	30	3 904	0 823	5.922	39.877	30	2 266	4 351	3.836	2.014
19 00	5 294	5 152	5.427	6.816	49 00	3 174	0 025	5.469	9.484	79 00	1 311	3 306	3.242	1.499
30	4 975	4 803	5.229	6.644	30	2 439	79 221	5.012	9.088	30	20 353	2 258	2.647	0.983
20 00	104 649	114 447	65.026	56.468	50 00	71 698	78 411	44.552	38.688	80 00	19 394	21 210	12.051	10.465
30	4 314	4 080	4.818	6.287	30	0 952	7 595	4.088	8.285	30	8 434	0 160	1.455	9.947
21 00	3 972	3 706	4.606	6.102	51 00	0 200	6 772	3.621	7.880	81 00	7 472	19 108	0.857	9.428
30	3 622	3 323	4.389	5.913	30	69 443	5 944	3.150	7.472	30	6 509	8 055	0.258	8.908
22 00	3 264	2 932	4.166	5.720	52 00	8 680	5 110	2.676	7.060	82 00	5 545	7 000	9.659	8.388
30	102 898	112 532	63.938	55.523	30	67 913	74 271	42.199	36.646	30	14 579	15 944	9.059	7.867
23 00	2 524	2 123	3.706	5.321	53 00	7 140	3 426	1.719	6.229	83 00	3 612	4 886	8.458	7.345
30	2 143	1 706	3.469	5.115	30	6 361	2 574	1.235	5.809	30	2 644	3 828	7.857	6.823
24 00	1 754	1 281	3.228	4.905	54 00	5 578	1 718	0.749	5.386	84 00	1 675	2 768	7.255	6.300
30	1 357	0 846	2.981	4.691	30	4 790	70 856	40.259	4.960	30	10 706	1 707	6.652	5.776
25 00	100 952	110 403	62.729	54.473	55 00	63 996	69 988	39.766	34.532	85 00	9 735	10 646	6.049	5.253
30	0 539	109 952	2.473	4.250	30	3 198	9 115	9.270	4.101	30	8 764	9 585	5.446	4.729
26 00	0 119	9 494	2.212	4.024	56 00	2 395	8 237	8.771	3.668	86 00	7 792	8 522	4.842	4.205
30	99 692	9 025	1.946	3.793	30	1 587	7 353	8.269	3.232	30	6 819	7 457	4.237	3.680
27 00	9 257	8 550	1.676	3.558	57 00	60 774	6 464	7.764	2.794	87 00	5 846	6 393	3.632	3.154
30	98 814	108 065	61.401	53.319	30	59 957	65 570	37.256	32.353	30	4 872	5 328	3.027	2.629
28 00	8 364	7 573	1.122	3.076	58 00	9 135	4 671	6.745	1.909	88 00	3 898	4 263	2.422	2.103
30	7 906	7 072	0.837	2.829	30	8 309	3 768	6.232	1.463	30	2 924	3 197	1.817	1.578
29 00	7 441	6 564	0.548	2.578	59 00	7 478	2 859	5.716	1.015	89 00	1 949	2 131	1.211	1.052
30	6 968	6 046	60.254	2.323	30	6 642	1 945	5.196	0.564	30	975	1 066	0.606	0.526
30 00	96 488	105 521	59.956	52.064	60 00	55 802	61 026	34.674	30.110	90 00	0	0	0	0

LENGTHS OF DEGREES OF THE MERIDIAN.

Lat.	Meters.*	Yards.*	Statute miles.	Nautical miles.	Lat.	Meters.*	Yards.*	Statute miles.	Nautical miles.
°					°				
0	110 567.2	120 918.8	68.704	59.661	45	111 130.9	121 535.3	69.054	59.965
1	110 567.6	120 919.3	68.704	59.661	46	111 150.6	121 556.9	69.066	59.976
2	110 568.6	120 920.4	68.705	59.662	47	111 170.4	121 578.5	69.079	59.987
3	110 570.3	120 922.2	68.706	59.663	48	111 190.1	121 600.1	69.091	59.997
4	110 572.7	120 924.9	68.708	59.664	49	111 209.7	121 621.5	69.103	60.008
5	110 575.8	120 928.3	68.710	59.666	50	111 229.3	121 642.9	69.115	60.019
6	110 579.5	120 932.3	68.712	59.668	51	111 248.7	121 664.1	69.127	60.029
7	110 583.9	120 937.1	68.715	59.670	52	111 268.0	121 685.3	69.139	60.039
8	110 589.0	120 942.7	68.718	59.673	53	111 287.1	121 706.1	69.151	60.050
9	110 594.7	120 948.9	68.721	59.676	54	111 306.0	121 726.8	69.163	60.060
10	110 601.1	120 955.9	68.725	59.680	55	111 324.8	121 747.4	69.175	60.070
11	110 608.1	120 963.6	68.730	59.684	56	111 343.3	121 767.6	69.186	60.080
12	110 615.8	120 972.0	68.734	59.687	57	111 361.5	121 787.5	69.197	60.090
13	110 624.1	120 981.1	68.739	59.692	58	111 379.5	121 807.2	69.209	60.100
14	110 633.0	120 990.8	68.744	59.697	59	111 397.2	121 826.6	69.220	60.109
15	110 642.5	121 001.2	68.751	59.702	60	111 414.5	121 845.5	69.230	60.118
16	110 652.6	121 012.2	68.757	59.707	61	111 431.5	121 864.1	69.241	60.128
17	110 663.3	121 023.9	68.764	59.713	62	111 448.2	121 882.3	69.251	60.137
18	110 674.5	121 036.2	68.771	59.719	63	111 464.4	121 900.0	69.261	60.145
19	110 686.3	121 049.1	68.778	59.725	64	111 480.3	121 917.4	69.271	60.154
20	110 698.7	121 062.7	68.786	59.732	65	111 495.7	121 934.3	69.281	60.162
21	110 711.6	121 076.8	68.794	59.739	66	111 510.7	121 950.7	69.290	60.170
22	110 725.0	121 091.4	68.802	59.746	67	111 525.3	121 966.6	69.299	60.178
23	110 738.8	121 106.5	68.811	59.754	68	111 539.3	121 982.0	69.308	60.186
24	110 753.2	121 122.2	68.820	59.761	69	111 552.9	121 996.8	69.316	60.193
25	110 768.0	121 138.4	68.829	59.769	70	111 565.9	122 011.0	69.324	60.200
26	110 783.3	121 155.1	68.839	59.777	71	111 578.4	122 024.7	69.332	60.207
27	110 799.0	121 172.3	68.848	59.786	72	111 590.4	122 037.8	69.340	60.213
28	110 815.1	121 190.0	68.858	59.795	73	111 601.8	122 050.3	69.347	60.220
29	110 831.6	121 208.0	68.869	59.804	74	111 612.7	122 062.2	69.354	60.225
30	110 848.5	121 226.5	68.879	59.813	75	111 622.9	122 073.4	69.360	60.231
31	110 865.7	121 245.3	68.890	59.822	76	111 632.6	122 084.0	69.366	60.236
32	110 883.2	121 264.4	68.901	59.831	77	111 641.6	122 093.8	69.372	60.241
33	110 901.1	121 284.0	68.912	59.841	78	111 650.0	122 103.0	69.377	60.246
34	110 919.2	121 303.8	68.923	59.851	79	111 657.8	122 111.6	69.382	60.250
35	110 937.6	121 323.9	68.935	59.861	80	111 664.9	122 119.3	69.386	60.254
36	110 956.2	121 344.3	68.946	59.871	81	111 671.4	122 126.4	69.390	60.257
37	110 975.1	121 364.9	68.958	59.881	82	111 677.2	122 132.8	69.394	60.260
38	110 994.1	121 385.7	68.969	59.891	83	111 682.4	122 138.5	69.397	60.263
39	111 013.3	121 406.7	68.981	59.902	84	111 686.9	122 143.4	69.400	60.265
40	111 032.7	121 427.9	68.993	59.912	85	111 690.7	122 147.5	69.402	60.268
41	111 052.2	121 449.3	69.006	59.923	86	111 693.8	122 150.9	69.404	60.269
42	111 071.7	121 470.6	69.018	59.933	87	111 696.2	122 153.5	69.405	60.270
43	111 091.4	121 492.1	69.030	59.944	88	111 697.9	122 155.4	69.407	60.271
44	111 111.1	121 513.7	69.042	59.954	89	111 699.0	122 156.6	69.407	60.272
45	111 130.9	121 535.3	69.054	59.965	90	111 699.3	122 156.9	69.407	60.272

*These quantities express the number of meters, yards, statute miles and nautical miles contained within an arc of which the degree of latitude named is the middle; thus, the quantity, 111032.7, opposite latitude 40°, is the number of meters between latitude 39° 30′ and latitude 40° 30′.

Latitude 0° to 1°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
0 00	30.92	61.84	92.77	123.69	154.61	185.53	216.46	247.38	278.30	1855.3	3710.7	5566.0	7421.4	9276.7
1	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
2	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
3	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
4	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
0 05	30.92	61.84	92.77	123.69	154.61	185.53	216.46	247.38	278.30	1855.3	3710.7	5566.0	7421.4	9276.7
6	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
7	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
8	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
9	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
0 10	30.92	61.84	92.77	123.69	154.61	185.53	216.46	247.38	278.30	1855.3	3710.7	5566.0	7421.3	9276.7
11	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.3	6.7
12	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.3	6.7
13	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.3	6.7
14	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.3	6.7
0 15	30.92	61.84	92.77	123.69	154.61	185.53	216.45	247.38	278.30	1855.3	3710.7	5566.0	7421.3	9276.6
16	.92	.84	.77	.69	.61	.53	.45	.38	.30	5.3	0.7	6.0	1.3	6.6
17	.92	.84	.77	.69	.61	.53	.45	.38	.30	5.3	0.6	6.0	1.3	6.6
18	.92	.84	.77	.69	.61	.53	.45	.38	.30	5.3	0.6	6.0	1.3	6.6
19	.92	.84	.77	.69	.61	.53	.45	.38	.30	5.3	0.6	6.0	1.3	6.6
0 20	30.92	61.84	92.77	123.69	154.61	185.53	216.45	247.38	278.30	1855.3	3710.6	5565.9	7421.2	9276.6
21	.92	.84	.77	.69	.61	.53	.45	.37	.30	5.3	0.6	5.9	1.2	6.6
22	.92	.84	.77	.69	.61	.53	.45	.37	.30	5.3	0.6	5.9	1.2	6.5
23	.92	.84	.77	.69	.61	.53	.45	.37	.30	5.3	0.6	5.9	1.2	6.5
24	.92	.84	.77	.69	.61	.53	.45	.37	.30	5.3	0.6	5.9	1.2	6.5
0 25	30.92	61.84	92.76	123.68	154.61	185.53	216.45	247.37	278.30	1855.3	3710.6	5565.9	7421.2	9276.5
26	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	0.6	5.9	1.2	6.5
27	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	0.6	5.9	1.1	6.4
28	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	0.6	5.9	1.1	6.4
29	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	0.6	5.8	1.1	6.4
0 30	30.92	61.84	92.76	123.68	154.61	185.53	216.45	247.37	278.29	1855.3	3710.5	5565.8	7421.1	9276.4
31	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	0.5	5.8	1.1	6.4
32	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	0.5	5.8	1.0	6.3
33	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	0.5	5.8	1.0	6.3
34	.92	.84	.76	.68	.60	.53	.45	.37	.29	5.3	0.5	5.8	1.0	6.3
0 35	30.92	61.84	92.76	123.68	154.60	185.52	216.45	247.37	278.29	1855.2	3710.5	5565.7	7421.0	9276.3
36	.92	.84	.76	.68	.60	.52	.44	.37	.29	5.2	0.5	5.7	1.0	6.2
37	.92	.84	.76	.68	.60	.52	.44	.36	.29	5.2	0.5	5.7	1.0	6.2
38	.92	.84	.76	.68	.60	.52	.44	.36	.29	5.2	0.5	5.7	0.9	6.2
39	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.5	5.7	0.9	6.1
0 40	30.92	61.84	92.76	123.68	154.60	185.52	216.44	247.36	278.28	1855.2	3710.4	5565.7	7420.9	9276.1
41	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.4	5.6	0.9	6.1
42	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.4	5.6	0.8	6.0
43	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.4	5.6	0.8	6.0
44	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.4	5.6	0.8	6.0
0 45	30.92	61.84	92.76	123.68	154.60	185.52	216.44	247.36	278.28	1855.2	3710.4	5565.6	7420.7	9275.9
46	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.4	5.5	0.7	5.9
47	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.3	5.5	0.7	5.9
48	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	0.3	5.5	0.7	5.8
49	.92	.84	.76	.68	.60	.52	.44	.35	.27	5.2	0.3	5.5	0.6	5.8
0 50	30.92	61.84	92.76	123.68	154.60	185.51	216.43	247.35	278.27	1855.1	3710.3	5565.4	7420.6	9275.7
51	.92	.84	.76	.68	.60	.51	.43	.35	.27	5.1	0.3	5.4	0.6	5.7
52	.92	.84	.76	.68	.59	.51	.43	.35	.27	5.1	0.3	5.4	0.5	5.7
53	.92	.84	.76	.68	.59	.51	.43	.35	.27	5.1	0.3	5.4	0.5	5.6
54	.92	.84	.76	.67	.59	.51	.43	.35	.27	5.1	0.2	5.4	0.5	5.6
0 55	30.92	61.84	92.76	123.67	154.59	185.51	216.43	247.35	278.27	1855.1	3710.2	5565.3	7420.4	9275.5
56	.92	.84	.75	.67	.59	.51	.43	.35	.27	5.1	0.2	5.3	0.4	5.5
57	.92	.84	.75	.67	.59	.51	.43	.35	.26	5.1	0.2	5.3	0.4	5.5
58	.92	.84	.75	.67	.59	.51	.43	.34	.26	5.1	0.2	5.2	0.3	5.4
59	.92	.84	.75	.67	.59	.51	.43	.34	.26	5.1	0.1	5.2	0.3	5.4
0 60	30.92	61.84	92.75	123.67	154.59	185.51	216.42	247.34	278.26	1855.1	3710.1	5565.2	7420.3	9275.3

Lat.	Latitude 0° to 1°—Meridional arcs.						Latitude 0°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
0 00	30.713								
1	3	1	30.71	1842.79	1	1 842.8	0 1	1 855.3	0.0
2	3	2	61.43	.79	2	3 685.6	2	3 710.7	
3	3	3	92.14	.79	3	5 528.4	3	5 566.0	
4	3	4	122.85	.79	4	7 371.1	4	7 421.4	
0 05	30.713	5	153.56	1842.79	5	9 213.9	0 5	9 276.7	0.0
6	3	6	184.28	.79	6	11 056.7	6	11 132.1	
7	3	7	214.99	.79	7	12 899.5	7	12 987.4	
8	3	8	245.70	.79	8	14 742.3	8	14 842.8	
9	3	9	276.42	.79	9	16 585.1	9	16 698.1	
0 10	30.713	10	307.13	1842.79	10	18 427.9	0 10	18 553.4	0.0
11	3	1	337.84	.79	1	20 270.7	15	27 830.2	
12	3	2	368.56	.79	2	22 113.4	20	37 106.9	
13	3	3	399.27	.79	3	23 956.2	25	46 383.6	
14	3	4	429.98	.79	4	25 799.0	30	55 660.3	
0 15	30.713	15	460.69	1842.79	15	27 641.8	0 35	64 937.1	0.0
16	3	6	491.41	.79	6	29 484.6	40	74 213.8	
17	3	7	522.12	.79	7	31 327.4	45	83 490.5	
18	3	8	552.83	.79	8	33 170.2	50	92 767.2	
19	3	9	583.55	.79	9	35 013.0	55	102 044.0	
0 20	30.713	20	614.26	1842.79	20	36 855.8	1 00	111 320.7	0.0
21	3	1	644.97	.79	1	38 698.5	05	120 597.4	
22	3	2	675.69	.79	2	40 541.3	10	129 874.1	
23	3	3	706.40	.79	3	42 384.1	15	139 150.9	
24	3	4	737.11	.79	4	44 226.9	20	148 427.6	
0 25	30.713	25	767.82	1842.79	25	46 069.7	1 25	157 704.3	0 0
26	3	6	798.54	.79	6	47 912.5	30	166 981.0	
27	3	7	829.25	.79	7	49 755.3	35	176 257.8	
28	3	8	859.96	.79	8	51 598.1	40	185 534.5	
29	3	9	890.68	.79	9	53 440.9	45	194 811.2	
0 30	30.713	30	921.39	1842.79	30	55 283.6	1 50	204 087.9	0.0
31	3	1	952.10	.79	1	57 126.4	55	213 364.7	
32	3	2	982.82	.79	2	58 969.2	2 00	222 641	
33	3	3	1 013.53	.79	3	60 812.0	3 00	333 962	
34	3	4	1 044.24	.79	4	62 654.8	4 00	445 283	
0 35	30.713	35	1 074.95	1842.79	35	64 497.6	5 00	556 603	0.0
36	3	6	1 105.67	.79	6	66 340.4	6 00	667 924	
37	3	7	1 136.38	.79	7	68 183.2	7 00	779 245	
38	3	8	1 167.09	.79	8	70 026.0	8 00	890 566	
39	3	9	1 197.81	.79	9	71 868.7	9 00	1 001 886	
0 40	30.713	40	1 228.52	1842.79	40	73 711.5	10 00	1 113 207	0.0
41	3	1	1 259.23	.79	1	75 554.3	11 00	1 224 528	
42	3	2	1 289.95	.79	2	77 397.1	12 00	1 335 848	
43	3	3	1 320.66	.79	3	79 239.9	13 00	1 447 169	
44	3	4	1 351.37	.79	4	81 082.7	14 00	1 558 490	
0 45	30.713	45	1 382.08	1842.79	45	82 925.5	15 00	1 669 810	0.0
46	3	6	1 412.80	.79	6	84 768.3	16 00	1 781 131	
47	3	7	1 443.51	.79	7	86 611.0	17 00	1 892 452	
48	3	8	1 474.22	.79	8	88 453.8	18 00	2 003 772	
49	3	9	1 504.94	.79	9	90 296.6	19 00	2 115 093	
0 50	30.713	50	1 535.65	1842.79	50	92 139.4	20 00	2 226 414	0.0
51	3	1	1 566.36	.79	1	93 982.2	21 00	2 337 735	
52	3	2	1 597.08	.79	2	95 825.0	22 00	2 449 055	
53	3	3	1 627.79	.79	3	97 667.8	23 00	2 560 376	
54	3	4	1 658.50	.79	4	99 510.6	24 00	2 671 697	
0 55	30.713	55	1 689.21	1842.79	55	101 353.4	25 00	2 783 017	0.0
56	3	6	1 719.93	.79	6	103 196.2	26 00	2 894 338	
57	3	7	1 750.64	.79	7	105 038.9	27 00	3 005 659	
58	3	8	1 781.35	.79	8	106 881.7	28 00	3 116 979	
59	3	9	1 812.07	.79	9	108 724.5	29 00	3 228 300	
0 60	30.713	60	1 842.79	1842.79	60	110 567.3	30 00	3 339 621	0.0

Latitude 1° to 2°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
1 00	30.92	61.84	92.75	123.67	154.59	185.51	216.42	247.34	278.26	1855.1	3710.1	5565.2	7420.3	9275.3
1	.92	.84	.75	.67	.59	.51	.42	.34	.26	5.1	0.1	5.2	0.2	5.3
2	.92	.83	.75	.67	.59	.50	.42	.34	.26	5.0	0.1	5.1	0.2	5.2
3	.92	.83	.75	.67	.59	.50	.42	.34	.26	5.0	0.1	5.1	0.1	5.2
4	.92	.83	.75	.67	.59	.50	.42	.34	.25	5.0	0.0	5.1	0.1	5.1
1 05	30.92	61.83	92.75	123.67	154.58	185.50	216.42	247.34	278.25	1855.0	3710.0	5565.0	7420.1	9275.1
6	.92	.83	.75	.67	.58	.50	.42	.33	.25	5.0	0.0	5.0	0.0	5.0
7	.92	.83	.75	.67	.58	.50	.42	.33	.25	5.0	0.0	5.0	0.0	5.0
8	.92	.83	.75	.67	.58	.50	.41	.33	.25	5.0	10.0	5.0	19.9	4.9
9	.92	.83	.75	.66	.58	.50	.41	.33	.24	5.0	9.9	4.9	9.9	4.9
1 10	30.92	61.83	92.75	123.66	154.58	185.50	216.41	247.33	278.24	1855.0	3709.9	5564.9	7419.9	9274.8
11	.92	.83	.75	.66	.58	.50	.41	.33	.24	5.0	9.9	4.9	9.8	4.8
12	.92	.83	.75	.66	.58	.49	.41	.33	.24	4.9	9.9	4.8	9.8	4.7
13	.92	.83	.75	.66	.58	.49	.41	.32	.24	4.9	9.8	4.8	9.7	4.6
14	.92	.83	.75	.66	.58	.49	.41	.32	.24	4.9	9.8	4.8	9.7	4.6
1 15	30.92	61.83	92.75	123.66	154.58	185.49	216.41	247.32	278.24	1854.9	3709.8	5564.7	7419.6	9274.5
16	.91	.83	.74	.66	.57	.49	.40	.32	.23	4.9	9.8	4.7	9.6	4.5
17	.91	.83	.74	.66	.57	.49	.40	.32	.23	4.9	9.8	4.6	9.5	4.4
18	.91	.83	.74	.66	.57	.49	.40	.32	.23	4.9	9.7	4.6	9.5	4.4
19	.91	.83	.74	.66	.57	.49	.40	.31	.23	4.9	9.7	4.6	9.4	4.3
1 20	30.91	61.83	92.74	123.66	154.57	185.48	216.40	247.31	278.23	1854.8	3709.7	5564.5	7419.4	9274.2
21	.91	.83	.74	.66	.57	.48	.40	.31	.23	4.8	9.7	4.5	9.3	4.2
22	.91	.83	.74	.65	.57	.48	.40	.31	.22	4.8	9.6	4.5	9.3	4.1
23	.91	.83	.74	.65	.57	.48	.39	.31	.22	4.8	9.6	4.4	9.2	4.0
24	.91	.83	.74	.65	.57	.48	.39	.31	.22	4.8	9.6	4.4	9.2	4.0
1 25	30.91	61.83	92.74	123.65	154.57	185.48	216.39	247.30	278.22	1854.8	3709.6	5564.3	7419.1	9273.9
26	.91	.83	.74	.65	.56	.48	.39	.30	.22	4.8	9.5	4.3	9.1	3.8
27	.91	.83	.74	.65	.56	.48	.39	.30	.21	4.8	9.5	4.3	9.0	3.8
28	.91	.82	.74	.65	.56	.47	.39	.30	.21	4.7	9.5	4.2	9.0	3.7
29	.91	.82	.74	.65	.56	.47	.38	.30	.21	4.7	9.5	4.2	8.9	3.6
1 30	30.91	61.82	92.74	123.65	154.56	185.47	216.38	247.30	278.21	1854.7	3709.4	5564.1	7418.9	9273.6
31	.91	.82	.73	.65	.56	.47	.38	.29	.20	4.7	9.4	4.1	8.8	3.5
32	.91	.82	.73	.65	.56	.47	.38	.29	.20	4.7	9.4	4.1	8.8	3.4
33	.91	.82	.73	.64	.56	.47	.38	.29	.20	4.7	9.3	4.0	8.7	3.4
34	.91	.82	.73	.64	.55	.47	.38	.29	.20	4.7	9.3	4.0	8.6	3.3
1 35	30.91	61.82	92.73	123.64	154.55	185.46	216.37	247.29	278.20	1854.6	3709.3	5563.9	7418.6	9273.2
36	.91	.82	.73	.64	.55	.46	.37	.28	.19	4.6	9.2	3.9	8.5	3.1
37	.91	.82	.73	.64	.55	.46	.37	.28	.19	4.6	9.2	3.8	8.4	3.1
38	.91	.82	.73	.64	.55	.46	.37	.28	.19	4.6	9.2	3.8	8.4	3.0
39	.91	.82	.73	.64	.55	.46	.37	.28	.19	4.6	9.2	3.7	8.3	2.9
1 40	30.91	61.82	92.73	123.64	154.55	185.46	216.37	247.28	278.18	1854.6	3709.1	5563.7	7418.3	9272.8
41	.91	.82	.73	.64	.55	.45	.36	.27	.18	4.5	9.1	3.6	8.2	2.7
42	.91	.82	.73	.64	.54	.45	.36	.27	.18	4.5	9.0	3.6	8.1	2.7
43	.91	.82	.73	.63	.54	.45	.36	.27	.18	4.5	9.0	3.6	8.1	2.6
44	.91	.82	.73	.63	.54	.45	.36	.27	.18	4.5	9.0	3.5	8.0	2.5
1 45	30.91	61.82	92.72	123.63	154.54	185.45	216.36	247.26	278.17	1854.5	3708.9	5563.5	7417.9	9272.4
46	.91	.82	.72	.63	.54	.45	.35	.26	.17	4.5	8.9	3.4	7.9	2.3
47	.91	.82	.72	.63	.54	.45	.35	.26	.17	4.5	8.9	3.4	7.8	2.3
48	.91	.81	.72	.63	.54	.44	.35	.26	.17	4.4	8.9	3.3	7.7	2.2
49	.91	.81	.72	.63	.53	.44	.35	.26	.16	4.4	8.8	3.3	7.7	2.1
1 50	30.91	61.81	92.72	123.63	154.53	185.44	216.35	247.25	278.16	1854.4	3708.8	5563.2	7417.6	9272.0
51	.91	.81	.72	.63	.53	.44	.34	.25	.16	4.4	8.8	3.1	7.5	1.9
52	.91	.81	.72	.62	.53	.44	.34	.25	.15	4.4	8.7	3.1	7.4	1.8
53	.91	.81	.72	.62	.53	.43	.34	.25	.15	4.3	8.7	3.0	7.4	1.7
54	.91	.81	.72	.62	.53	.43	.34	.24	.15	4.3	8.7	3.0	7.3	1.7
1 55	30.91	61.81	92.72	123.62	154.53	185.43	216.34	247.24	278.15	1854.3	3708.6	5562.9	7417.3	9271.6
56	.90	.81	.71	.62	.52	.43	.33	.24	.14	4.3	8.6	2.9	7.2	1.5
57	.90	.81	.71	.62	.52	.43	.33	.24	.14	4.3	8.5	2.8	7.1	1.4
58	.90	.81	.71	.62	.52	.43	.33	.23	.14	4.3	8.5	2.8	7.0	1.3
59	.90	.81	.71	.62	.52	.42	.33	.23	.14	4.2	8.5	2.7	7.0	1.2
1 60	30.90	61.81	92.71	123.61	154.52	185.42	216.33	247.23	278.13	1854.2	3708.4	5562.7	7416.9	9271.1

Lat.	Latitude 1° to 2°—Meridional arcs.						Latitude 1°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
1 00	30.713			1842.79					
1	3	1	30.71	.79	1	1 842.8	0 1	1 855.1	0.0
2	3	2	61.43	.79	2	3 685.6	2	3 710.1	0.0
3	3	3	92.14	.79	3	5 528.4	3	5 565.2	0.0
4	3	4	122.85	.79	4	7 371.2	4	7 420.3	0.1
1 05	30.713	5	153.57	1842.79	5	9 214.0	0 5	9 275.3	0.1
6	3	6	184.28	.79	6	11 056.8	6	11 130.4	0.2
7	3	7	215.00	.79	7	12 899.6	7	12 985.4	0.2
8	3	8	245.71	.79	8	14 742.3	8	14 840.5	0.3
9	3	9	276.42	.79	9	16 585.1	9	16 695.6	0.4
1 10	30.713	10	307.14	1842.79	10	18 427.9	0 10	18 550.6	0.5
11	3	1	337.85	.79	11	20 270.7	15	27 826.0	1.1
12	3	2	368.56	.80	12	22 113.5	20	37 101.3	1.9
13	3	3	399.28	.80	13	23 956.3	25	46 376.6	2.9
14	3	4	429.99	.80	14	25 799.1	30	55 651.9	4.2
1 15	30.713	15	460.70	1842.80	15	27 641.9	0 35	64 927.2	5.8
16	3	6	491.42	.80	16	29 484.7	40	74 202.5	7.5
17	3	7	522.13	.80	17	31 327.5	45	83 477.8	9.5
18	3	8	552.84	.80	18	33 170.3	50	92 753.2	11.7
19	3	9	583.56	.80	19	35 013.1	55	102 028.5	14.2
1 20	30.713	20	614.27	1842.80	20	36 855.9	1 00	111 303.7	16.9
21	3	1	644.98	.80	21	38 698.7	05	120 579.0	19.9
22	3	2	675.70	.80	22	40 541.5	10	129 854.3	23.0
23	3	3	706.41	.80	23	42 384.3	15	139 129.6	26.4
24	3	4	737.12	.80	24	44 227.1	20	148 404.9	30.1
1 25	30.713	25	767.84	1842.80	25	46 069.9	1 25	157 680.2	34.0
26	3	6	798.55	.80	26	47 912.7	30	166 955.5	38.1
27	3	7	829.26	.80	27	49 755.5	35	176 230.8	42.4
28	3	8	859.98	.80	28	51 598.3	40	185 506.1	47.0
29	3	9	890.69	.80	29	53 441.1	45	194 781.4	51.8
1 30	30.713	30	921.40	1842.80	30	55 283.9	1 50	204 056.7	56.9
31	3	1	952.12	.80	31	57 126.7	55	213 331.9	62.2
32	3	2	982.83	.80	32	58 969.5	2 00	222 607	68
33	3	3	1 013.54	.80	33	60 812.3	3 00	333 911	153
34	3	4	1 044.26	.80	34	62 655.1	4 00	445 214	271
1 35	30.713	35	1 074.97	1842.80	35	64 497.9	5 00	556 518	424
36	3	6	1 105.68	.80	36	66 340.7	6 00	667 822	610
37	3	7	1 136.40	.80	37	68 183.5	7 00	779 126	831
38	3	8	1 167.11	.80	38	70 026.3	8 00	890 429	1 085
39	3	9	1 197.82	.80	39	71 869.1	9 00	1 001 733	1 373
1 40	30.713	40	1 228.54	1842.80	40	73 711.9	10 00	1 113 037	1 695
41	3	1	1 259.25	.80	41	75 554.7	11 00	1 224 340	2 051
42	3	2	1 289.96	.80	42	77 397.5	12 00	1 335 643	2 441
43	3	3	1 320.68	.80	43	79 240.3	13 00	1 446 946	2 865
44	3	4	1 351.39	.81	44	81 083.1	14 00	1 558 249	3 323
1 45	30.713	45	1 382.10	1842.81	45	82 925.9	15 00	1 669 551	3 814
46	3	6	1 412.82	.81	46	84 768.7	16 00	1 780 854	4 340
47	3	7	1 443.53	.81	47	86 611.5	17 00	1 892 157	4 899
48	3	8	1 474.24	.81	48	88 454.3	18 00	2 003 459	5 492
49	3	9	1 504.96	.81	49	90 297.1	19 00	2 114 761	6 120
1 50	30.713	50	1 535.67	1842.81	50	92 139.9	20 00	2 226 063	6 781
51	3	1	1 566.38	.81	51	93 982.7	21 00	2 337 364	7 476
52	3	2	1 597.10	.81	52	95 825.6	22 00	2 448 666	8 205
53	3	3	1 627.81	.81	53	97 668.4	23 00	2 559 967	8 967
54	3	4	1 658.52	.81	54	99 511.2	24 00	2 671 268	9 764
1 55	30.713	55	1 689.23	1842.81	55	101 354.0	25 00	2 782 569	10 595
56	3	6	1 719.95	.81	56	103 196.8	26 00	2 893 869	11 450
57	3	7	1 750.66	.81	57	105 039.6	27 00	3 005 170	12 358
58	3	8	1 781.37	.81	58	106 882.4	28 00	3 116 470	13 2[illegible]
59	3	9	1 812.09	.81	59	108 725.2	29 00	3 227 770	14 259
1 60	30.713	60	1 842.80	1842.81	60	110 568.0	30 00	3 330 070	15 256

Latitude 2° to 3°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
2 00	30.90	61.81	92.71	123.61	154.52	185.42	216.33	247.23	278.13	1854.2	3708.4	5562.7	7416.9	9271.1
1	.90	.81	.71	.61	.52	.42	.33	.23	.13	4.2	8.4	2.6	6.8	1.0
2	.90	.81	.71	.61	.52	.42	.32	.22	.12	4.2	8.3	2.6	6.7	0.9
3	.90	.81	.71	.61	.51	.41	.32	.22	.12	4.1	8.3	2.5	6.7	0.8
4	.90	.81	.71	.61	.51	.41	.32	.22	.12	4.1	8.2	2.5	6.6	0.7
2 05	30.90	61.81	92.71	123.61	154.51	185.41	216.31	247.21	278.11	1854.1	3708.2	5562.4	7416.5	9270.6
6	.90	.80	.70	.60	.51	.41	.31	.21	.11	4.1	8.2	2.3	6.4	0.5
7	.90	.80	.70	.60	.51	.41	.31	.21	.11	4.1	8.2	2.3	6.3	0.4
8	.90	.80	.70	.60	.50	.40	.31	.21	.11	4.0	8.1	2.2	6.3	0.3
9	.90	.80	.70	.60	.50	.40	.30	.20	.10	4.0	8.1	2.2	6.2	0.2
2 10	30.90	61.80	92.70	123.60	154.50	185.40	216.30	247.20	278.10	1854.0	3708.1	5562.1	7416.1	9270.1
11	.90	.80	.70	.60	.50	.40	.30	.20	.10	4.0	8.0	2.0	6.0	70.0
12	.90	.80	.70	.60	.50	.40	.30	.20	.09	4.0	8.0	2.0	5.9	69.9
13	.90	.80	.70	.60	.50	.39	.29	.19	.09	3.9	7.9	1.9	5.9	9.8
14	.90	.80	.70	.60	.50	.39	.29	.19	.09	3.9	7.9	1.9	5.8	9.7
2 15	30.90	61.80	92.70	123.60	154.50	185.39	216.29	247.19	278.08	1853.9	3707.8	5561.8	7415.7	9269.6
16	.90	.79	.69	.59	.49	.39	.29	.19	.08	3.9	7.8	1.7	5.6	9.5
17	.90	.79	.69	.59	.49	.39	.29	.19	.08	3.9	7.7	1.7	5.5	9.4
18	.90	.79	.69	.59	.49	.38	.28	.18	.08	3.8	7.7	1.6	5.5	9.3
19	.90	.79	.69	.59	.49	.38	.28	.18	.07	3.8	7.6	1.6	5.4	9.2
2 20	30.90	61.79	92.69	123.59	154.49	185.38	216.28	247.18	278.07	1853.8	3707.6	5561.5	7415.3	9269.1
21	.90	.79	.69	.59	.49	.38	.28	.18	.07	3.8	7.6	1.4	5.2	9.0
22	.90	.79	.69	.59	.49	.38	.27	.17	.06	3.8	7.5	1.3	5.1	8.9
23	.90	.79	.69	.58	.48	.37	.27	.17	.06	3.7	7.5	1.3	5.0	8.7
24	.90	.79	.69	.58	.48	.37	.27	.17	.06	3.7	7.4	1.2	4.9	8.6
2 25	30.90	61.79	92.69	123.58	154.48	185.37	216.26	247.16	278.05	1853.7	3707.4	5561.1	7414.8	9268.5
26	.89	.79	.68	.58	.48	.37	.26	.16	.05	3.7	7.4	1.0	4.7	8.4
27	.89	.79	.68	.58	.48	.37	.26	.16	.05	3.7	7.3	1.0	4.6	8.3
28	.89	.79	.68	.57	.47	.36	.26	.16	.05	3.6	7.3	0.9	4.6	8.2
29	.89	.79	.68	.57	.47	.36	.25	.15	.04	3.6	7.2	0.9	4.5	8.1
2 30	30.89	61.79	92.68	123.57	154.47	185.36	216.25	247.15	278.04	1853.6	3707.2	5560.8	7414.4	9268.0
31	.89	.79	.68	.57	.47	.36	.25	.15	.04	3.6	7.1	0.7	4.3	7.9
32	.89	.79	.68	.57	.47	.35	.24	.14	.03	3.5	7.1	0.6	4.2	7.7
33	.89	.79	.68	.57	.46	.35	.24	.14	.03	3.5	7.0	0.6	4.0	7.6
34	.89	.79	.67	.57	.46	.35	.24	.13	.02	3.5	7.0	0.5	3.9	7.4
2 35	30.89	61.79	92.67	123.57	154.46	185.35	216.23	247.13	278.02	1853.5	3706.9	5560.4	7413.8	9267.3
36	.89	.78	.67	.56	.46	.34	.23	.13	.02	3.4	6.9	0.3	3.7	7.2
37	.89	.78	.67	.56	.46	.34	.23	.12	.01	3.4	6.8	0.2	3.6	7.1
38	.89	.78	.67	.56	.45	.34	.23	.12	.01	3.4	6.8	0.2	3.6	6.9
39	.89	.78	.67	.56	.45	.33	.22	.11	.00	3.3	6.7	0.1	3.5	6.8
2 40	30.89	61.78	92.67	123.56	154.45	185.33	216.22	247.11	278.00	1853.3	3706.7	5560.0	7413.4	9266.7
41	.89	.78	.67	.56	.45	.33	.22	.11	8.00	3.3	6.6	59.9	3.3	6.6
42	.89	.78	.67	.56	.44	.33	.21	.10	7.99	3.3	6.6	9.8	3.2	6.5
43	.89	.78	.66	.55	.44	.32	.21	.10	.99	3.2	6.5	9.8	3.0	6.3
44	.89	.78	.66	.55	.44	.32	.21	.10	.98	3.2	6.5	9.7	2.9	6.2
2 45	30.89	61.78	92.66	123.55	154.43	185.32	216.20	247.09	277.98	1853.2	3706.4	5559.6	7412.8	9266.1
46	.88	.77	.66	.55	.43	.32	.20	.09	.98	3.2	6.4	9.5	2.7	6.0
47	.88	.77	.66	.55	.43	.32	.20	.09	.97	3.2	6.3	9.5	2.6	5.9
48	.88	.77	.66	.54	.43	.31	.20	.09	.97	3.1	6.3	9.4	2.6	5.7
49	.88	.77	.66	.54	.42	.31	.19	.08	.96	3.1	6.2	9.4	2.5	5.6
2 50	30.88	61.77	92.65	123.54	154.42	185.31	216.19	247.08	277.96	1853.1	3706.2	5559.3	7412.4	9265.5
51	.88	.77	.65	.54	.42	.31	.19	.08	.96	3.1	6.1	9.2	2.3	5.3
52	.88	.77	.65	.54	.42	.31	.18	.07	.95	3.0	6.1	9.1	2.2	5.2
53	.88	.77	.65	.53	.41	.30	.18	.07	.95	3.0	6.0	9.1	2.0	5.0
54	.88	.77	.65	.53	.41	.30	.18	.06	.94	3.0	6.0	9.0	1.9	4.9
2 55	30.88	61.77	92.65	123.53	154.41	185.29	216.17	247.06	277.94	1852.9	3705.9	5558.9	7411.8	9264.7
56	.88	.76	.65	.53	.41	.29	.17	.06	.94	2.9	5.8	8.8	1.7	4.6
57	.88	.76	.64	.53	.41	.29	.17	.05	.93	2.9	5.8	8.7	1.6	4.5
58	.88	.76	.64	.52	.40	.29	.17	.05	.93	2.9	5.7	8.7	1.5	4.3
59	.88	.76	.64	.52	.40	.28	.16	.04	.92	2.8	5.7	8.6	1.4	4.2
2 60	30.88	61.76	92.64	123.52	154.40	185.28	216.16	247.04	277.92	1852.8	3705.6	5558.5	7411.3	9264.1

Lat.		Latitude 2° to 3°—Meridional arcs.						Latitude 2°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
2	00	30.714			1842.81						
	1	4	1	30.71	.81	1	1 842.8	0	1	1 854.2	
	2	4	2	61.43	.81	2	3 685.6		2	3 708.4	
	3	4	3	92.14	.81	3	5 528.4		3	5 562.7	0.1
	4	4	4	122.86	.81	4	7 371.2		4	7 416.9	0.2
2	5	30.714	5	153.57	1842.81	5	9 214.1	0	5	9 271.1	0.2
	6	4	6	184.28	.81	6	11 056.9		6	11 125.3	0.3
	7	4	7	215.00	.81	7	12 899.7		7	12 979.6	0.5
	8	4	8	245.71	.81	8	14 742.5		8	14 833.8	0.6
	9	4	9	276.43	.81	9	16 585.3		9	16 688.0	0.8
2	10	30.714	10	307.14	1842.81	10	18 428.1	0	10	18 542.2	0.9
	11	4	1	337.85	.81	1	20 270.9		15	27 813.3	2.1
	12	4	2	368.57	.81	2	22 113.8		20	37 084.4	3.8
	13	4	3	399.28	.81	3	23 956.6		25	46 355.6	5.9
	14	4	4	430.00	.81	4	25 799.4		30	55 626.7	8.5
2	15	30.714	15	460.71	1842.82	15	27 642.2	0	35	64 897.8	11.5
	16	4	6	491.42	.82	6	29 485.0		40	74 168.9	15.0
	17	4	7	522.14	.82	7	31 327.8		45	83 440.0	19.0
	18	4	8	552.85	.82	8	33 170.7		50	92 711.1	23.5
	19	4	9	583.57	.82	9	35 013.5		55	101 982.2	28.4
2	20	30.714	20	614.28	1842.82	20	36 856.3	1	00	111 253.4	33.9
	21	4	1	644.99	.82	1	38 699.1		05	120 524.5	39.8
	22	4	2	675.71	.82	2	40 541.9		10	129 795.6	46.1
	23	4	3	706.42	.82	3	42 384.8		15	139 066.7	52.9
	24	4	4	737.14	.82	4	44 227.6		20	148 337.8	60.2
2	25	30.714	25	767.85	1842.82	25	46 070.4	1	25	157 608.9	68.0
	26	4	6	798.56	.82	6	47 913.2		30	166 880.0	76.2
	27	4	7	829.28	.82	7	49 756.0		35	176 151.1	84.9
	28	4	8	859.99	.82	8	51 598.9		40	185 422.2	94.1
	29	4	9	890.71	.82	9	53 441.7		45	194 693.3	103.8
2	30	30.714	30	921.41	1842.82	30	55 284.5	1	50	203 964.5	113.9
	31	4	1	952.13	.82	1	57 127.3		55	213 235.6	124.5
	32	4	2	982.85	.82	2	58 970.1	2	00	222 506	136
	33	4	3	1 013.56	.82	3	60 813.0	3	00	333 759	305
	34	4	4	1 044.28	.82	4	62 655.8	4	00	445 012	542
2	35	30.714	35	1 074.99	1842.83	35	64 498.6	5	00	556 266	847
	36	4	6	1 105.70	.83	6	66 341.5	6	00	667 517	1 220
	37	4	7	1 136.42	.83	7	68 184.3	7	00	778 770	1 660
	38	4	8	1 167.13	.83	8	70 027.1	8	00	890 023	2 169
	39	4	9	1 197.85	.83	9	71 869.9	9	00	1 001 275	2 745
2	40	30.714	40	1 228.56	1842.83	40	73 712.8	10	00	1 112 527	3 388
	41	4	1	1 259.27	.83	1	75 555.6	11	00	1 223 778	4 100
	42	4	2	1 289.99	.83	2	77 398.4	12	00	1 335 028	4 879
	43	4	3	1 320.70	.83	3	79 241.3	13	00	1 446 278	5 726
	44	4	4	1 351.42	.83	4	81 084.1	14	00	1 557 528	6 641
2	45	30.714	45	1 382.13	1842.83	45	82 926.9	15	00	1 668 778	7 624
	46	4	6	1 412.84	.83	6	84 769.8	16	00	1 780 027	8 674
	47	4	7	1 443.56	.83	7	86 612.6	17	00	1 891 275	9 792
	48	4	8	1 474.27	.83	8	88 455.4	18	00	2 002 522	10 978
	49	4	9	1 504.99	.83	9	90 298.2	19	00	2 113 768	12 232
2	50	30.714	50	1 535.70	1842.83	50	92 141.1	20	00	2 225 012	13 553
	51	4	1	1 566.41	.83	1	93 983.9	21	00	2 336 257	14 942
	52	4	2	1 597.13	.84	2	95 826.7	22	00	2 447 501	16 399
	53	4	3	1 627.84	.84	3	97 669.5	23	00	2 558 744	17 923
	54	4	4	1 658.56	.84	4	99 512.4	24	00	2 669 986	19 515
2	55	30.714	55	1 689.27	1842.84	55	101 355.2	25	00	2 781 227	21 176
	56	4	6	1 719.98	.84	6	103 198.0	26	00	2 892 466	22 904
	57	4	7	1 750.70	.84	7	105 041.9	27	00	3 003 705	24 700
	58	4	8	1 781.41	.84	8	106 883.7	28	00	3 114 943	26 563
	59	4	9	1 812.13	.84	9	108 726.5	29	00	3 226 179	28 494
2	60	30.714	60	1 842.82	1842.84	60	110 569.4	30	00	3 337 415	30 494

Latitude 3° to 4°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
3 00	30.88	61.76	92.64	123.52	154.40	185.28	216.16	247.04	277.92	1852.8	3705.6	5558.5	7411.3	9264.1
1	.88	.76	.64	.52	.40	.28	.16	.04	.92	2.8	5.5	8.4	1.2	4.0
2	.88	.76	.64	.52	.40	.28	.15	.03	.91	2.8	5.5	8.3	1.1	3.8
3	.88	.76	.64	.51	.39	.27	.15	.03	.91	2.7	5.4	8.2	0.9	3.7
4	.88	.76	.64	.51	.39	.27	.15	.02	.90	2.7	5.4	8.1	0.8	3.5
3 05	30.88	61.76	92.63	123.51	154.39	185.27	216.14	247.02	277.90	1852.7	3705.3	5558.0	7410.7	9263.4
6	.88	.75	.63	.51	.39	.27	.14	.02	.90	2.7	5.3	7.9	0.6	3.3
7	.88	.75	.63	.51	.39	.26	.14	.01	.89	2.6	5.2	7.8	0.5	3.1
8	.88	.75	.63	.50	.38	.26	.14	.01	.89	2.6	5.2	7.8	0.3	3.0
9	.88	.75	.63	.50	.38	.25	.13	.00	.88	2.5	5.1	7.7	0.2	2.8
3 10	30.88	61.75	92.63	123.50	154.38	185.25	216.13	247.00	277.88	1852.5	3705.1	5557.6	7410.1	9262.7
11	.88	.75	.63	.50	.38	.25	.13	7.00	.88	2.5	5.0	7.5	10.0	2.5
12	.88	.75	.62	.50	.37	.25	.12	6.99	.87	2.5	5.0	7.4	09.9	2.4
13	.88	.75	.62	.49	.37	.24	.12	.99	.87	2.4	4.9	7.4	9.7	2.2
14	.88	.75	.62	.49	.37	.24	.11	.98	.86	2.4	4.9	7.3	9.6	2.1
3 15	30.88	61.75	92.62	123.49	154.36	185.24	216.11	246.98	277.86	1852.4	3704.8	5557.2	7409.5	9261.9
16	.87	.74	.62	.49	.36	.23	.11	.98	.85	2.3	4.7	7.1	9.4	1.7
17	.87	.74	.62	.49	.36	.23	.10	.97	.85	2.3	4.7	7.0	9.3	1.6
18	.87	.74	.61	.48	.36	.23	.10	.97	.84	2.3	4.6	6.9	9.1	1.4
19	.87	.74	.61	.48	.35	.22	.09	.96	.84	2.2	4.6	6.8	9.0	1.3
3 20	30.87	61.74	92.61	123.48	154.35	185.22	216.09	246.96	277.83	1852.2	3704.5	5556.7	7408.9	9261.1
21	.87	.74	.61	.48	.35	.22	.09	.96	.83	2.2	4.4	6.6	8.8	1.0
22	.87	.74	.61	.48	.35	.22	.08	.95	.82	2.2	4.3	6.5	8.7	0.8
23	.87	.74	.61	.47	.34	.21	.08	.95	.82	2.1	4.3	6.4	8.5	0.7
24	.87	.74	.61	.47	.34	.21	.08	.94	.81	2.1	4.2	6.3	8.4	0.5
3 25	30.87	61.74	92.60	123.47	154.34	185.21	216.07	246.94	277.81	1852.1	3704.1	5556.2	7408.3	9260.4
26	.87	.73	.60	.47	.34	.20	.07	.94	.81	2.1	4.0	6.1	8.2	0.2
27	.87	.73	.60	.47	.34	.20	.07	.93	.80	2.0	4.0	6.0	8.0	60.0
28	.87	.73	.60	.46	.33	.20	.07	.93	.80	2.0	3.9	5.9	7.9	59.9
29	.87	.73	.60	.46	.33	.19	.06	.92	.79	1.9	3.9	5.8	7.7	9.7
3 30	30.87	61.73	92.60	123.46	154.33	185.19	216.06	246.92	277.79	1851.9	3703.8	5555.7	7407.6	9259.5
31	.87	.73	.59	.46	.33	.19	.06	.92	.79	1.9	3.7	5.6	7.5	9.3
32	.87	.73	.59	.46	.32	.18	.05	.91	.78	1.8	3.7	5.5	7.4	9.2
33	.87	.73	.59	.45	.32	.18	.05	.91	.78	1.8	3.6	5.4	7.2	9.0
34	.87	.73	.59	.45	.32	.18	.04	.90	.77	1.7	3.6	5.3	7.1	8.9
3 35	30.87	61.73	92.59	123.45	154.31	185.17	216.04	246.90	277.77	1851.7	3703.5	5555.2	7407.0	9258.7
36	.86	.72	.59	.45	.31	.17	.04	.90	.76	1.7	3.4	5.1	6.9	8.5
37	.86	.72	.58	.45	.31	.17	.03	.89	.76	1.7	3.3	5.0	6.7	8.4
38	.86	.72	.58	.44	.31	.17	.03	.89	.75	1.6	3.3	4.9	6.6	8.2
39	.86	.72	.58	.44	.30	.16	.02	.88	.75	1.6	3.2	4.8	6.4	8.1
3 40	30.86	61.72	92.58	123.44	154.30	185.16	216.02	246.88	277.74	1851.6	3703.1	5554.7	7406.3	9257.9
41	.86	.72	.58	.44	.30	.16	.02	.88	.73	1.6	3.0	4.6	6.2	7.7
42	.86	.72	.58	.43	.29	.15	.01	.87	.73	1.5	3.0	4.5	6.0	7.5
43	.86	.71	.57	.43	.29	.15	.01	.87	.72	1.5	2.9	4.4	5.9	7.4
44	.86	.71	.57	.43	.29	.14	.00	.86	.72	1.4	2.9	4.3	5.7	7.2
3 45	30.86	61.71	92.57	123.42	154.28	185.14	216.00	246.86	277.71	1851.4	3702.8	5554.2	7405.6	9257.0
46	.85	.71	.57	.42	.28	.14	6.00	.85	.70	1.4	2.7	4.1	5.5	6.8
47	.85	.71	.57	.42	.28	.13	5.99	.85	.70	1.3	2.6	4.0	5.3	6.6
48	.85	.70	.57	.42	.28	.13	.99	.84	.69	1.3	2.6	3.9	5.1	6.5
49	.85	.70	.56	.41	.27	.12	.98	.84	.69	1.2	2.5	3.8	5.0	6.3
3 50	30.85	61.70	92.56	123.41	154.27	185.12	215.98	246.83	277.68	1851.2	3702.4	5553.7	7404.9	9256.1
51	.85	.70	.56	.41	.27	.12	.98	.83	.68	1.2	2.3	3.6	4.8	5.9
52	.85	.70	.56	.41	.26	.11	.97	.82	.67	1.1	2.3	3.5	4.6	5.7
53	.85	.70	.56	.40	.26	.11	.97	.82	.67	1.1	2.2	3.3	4.5	5.6
54	.85	.70	.55	.40	.26	.11	.96	.81	.66	1.0	2.2	3.2	4.3	5.4
3 55	30.85	61.70	92.55	123.40	154.25	185.10	215.96	246.81	277.66	1851.0	3702.1	5553.1	7404.2	9255.2
56	.85	.70	.55	.40	.25	.10	.95	.80	.65	1.0	2.0	3.0	4.0	5.0
57	.85	.70	.55	.40	.25	.10	.95	.80	.65	1.0	1.9	2.9	3.9	4.8
58	.85	.70	.55	.39	.25	.10	.94	.79	.64	0.9	1.9	2.8	3.7	4.7
59	.85	.70	.54	.39	.24	.09	.94	.79	.64	0.9	1.8	2.7	3.6	4.5
3 60	30.85	61.70	92.54	123.39	154.24	185.09	215.93	246.78	277.63	1850.9	3701.7	5552.6	7403.4	9254.3

Lat.	Latitude 3° to 4°—Meridional arcs.						Latitude 3°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
3 00	30.714			1842.84					
1	4	1	30.71	.84	1	1 842.8	0 1	1 852.8	
2	4	2	61.43	.84	2	3 685.7	2	3 705.6	0.1
3	4	3	92.14	.84	3	5 528.5	3	5 558.4	0.1
4	4	4	122.86	.84	4	7 371.4	4	7 411.3	0.2
3 05	30.714	5	153.57	1842.84	5	9 214.2	0 5	9 264.1	0.4
6	4	6	184.29	.84	6	11 057.0	6	11 116.9	0.5
7	4	7	215.00	.84	7	12 899.9	7	12 969.7	0.7
8	4	8	245.71	.84	8	14 742.7	8	14 822.5	0.9
9	4	9	276.43	.84	9	16 585.6	9	16 675.3	1.1
3 10	30.714	10	307.14	1842.84	10	18 428.4	0 10	18 528.1	1.4
11	4	1	337.86	.85	1	20 271.3	15	27 792.3	3.2
12	4	2	368.57	.85	2	22 114.1	20	37 056.4	5.6
13	4	3	399.29	.85	3	23 957.0	25	46 320.5	8.8
14	4	4	430.00	.85	4	25 799.8	30	55 584.6	12.7
3 15	30.714	15	460.71	1842.85	15	27 642.7	0 35	64 848.7	17.3
16	4	6	491.43	.85	6	29 485.5	40	74 112.8	22.6
17	4	7	522.14	.85	7	31 328.4	45	83 376.9	28.6
18	4	8	552.86	.85	8	33 171.2	50	92 641.1	35.3
19	4	9	583.57	.85	9	35 014.1	55	101 905.2	42.7
3 20	30.714	20	614.29	1842.85	20	36 856.9	1 00	111 169.3	50.8
21	4	1	645.00	.85	1	38 699.8	05	120 433.3	59.6
22	4	2	675.71	.85	2	40 542.6	10	129 697.4	69.1
23	4	3	706.43	.85	3	42 385.5	15	138 961.5	79.3
24	4	4	737.14	.85	4	44 228.3	20	148 225.7	90.3
3 25	30.714	25	767.86	1842.85	25	46 071.2	1 25	157 489.8	101.9
26	4	6	798.57	.85	6	47 914.0	30	166 753.9	114.2
27	4	7	829.29	.85	7	49 756.9	35	176 018.0	127.3
28	4	8	860.00	.86	8	51 599.7	40	185 282.0	141.0
29	4	9	890.71	.86	9	53 442.6	45	194 546.1	155.5
3 30	30.714	30	921.43	1842.86	30	55 285.5	1 50	203 810.1	170.7
31	4	1	952.14	.86	1	57 128.3	55	213 074.1	186.5
32	4	2	982.86	.86	2	58 971.2	2 00	222 338	203
33	4	3	1 013.57	.86	3	60 814.0	3 00	333 507	457
34	4	4	1 044.29	.86	4	62 656.9	4 00	444 676	812
3 35	30.714	35	1 075.00	1842.86	35	64 499.8	5 00	555 844	1 269
36	4	6	1 105.71	.86	6	66 342.6	6 00	667 012	1 828
37	4	7	1 136.43	.86	7	68 185.5	7 00	778 179	2 488
38	4	8	1 167.14	.86	8	70 028.3	8 00	889 346	3 249
39	4	9	1 197.86	.86	9	71 871.2	9 00	1 000 512	4 112
3 40	30.714	40	1 228.57	1842.86	40	73 714.1	10 00	1 111 677	5 077
41	4	1	1 259.29	.86	1	75 556.9	11 00	1 222 841	6 144
42	4	2	1 290.00	.86	2	77 399.8	12 00	1 334 005	7 312
43	4	3	1 320.71	.87	3	79 242.7	13 00	1 445 166	8 581
44	4	4	1 351.43	.87	4	81 085.5	14 00	1 556 327	9 952
3 45	30.714	45	1 382.14	1842.87	45	82 928.4	15 00	1 667 487	11 424
46	4	6	1 412.86	.87	6	84 771.3	16 00	1 778 645	12 998
47	4	7	1 443.57	.87	7	86 614.1	17 00	1 889 802	14 673
48	4	8	1 474.29	.87	8	88 457.0	18 00	2 000 957	16 450
49	4	9	1 505.00	.87	9	90 299.9	19 00	2 112 110	18 329
3 50	30.715	50	1 535.71	1842.87	50	92 142.7	20 00	2 223 260	20 309
51	5	1	1 566.43	.87	1	93 985.6	21 00	2 334 410	22 391
52	5	2	1 597.14	.87	2	95 828.4	22 00	2 445 557	24 574
53	5	3	1 627.86	.87	3	97 671.3	23 00	2 556 703	26 859
54	5	4	1 658.57	.87	4	99 514.2	24 00	2 667 846	29 245
3 55	30.715	55	1 689.29	1842.87	55	101 357.0	25 00	2 778 988	31 732
56	5	6	1 720.00	.87	6	103 199.9	26 00	2 890 127	34 321
57	5	7	1 750.71	.88	7	105 042.8	27 00	3 001 265	37 012
58	5	8	1 781.43	.88	8	106 885.7	28 00	3 112 399	39 804
59	5	9	1 812.14	.88	9	108 728.5	29 00	3 223 530	42 697
3 60	30.715	60	1 842.86	1842.88	60	110 571.4	30 00	3 334 659	45 693

Latitude 4° to 5°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
4 00	30.85	61.70	92.54	123.39	154.24	185.09	215.93	246.78	277.63	1850.9	3701.7	5552.6	7403.4	9254.3
1	.85	.70	.54	.39	.24	.09	.93	.78	.62	0.9	1.6	2.5	3.3	4.1
2	.85	.70	.54	.39	.23	.08	.92	.77	.62	0.8	1.6	2.4	3.1	3.9
3	.85	.69	.54	.38	.23	.08	.92	.77	.61	0.8	1.5	2.2	3.0	3.8
4	.85	.69	.54	.38	.23	.07	.91	.76	.61	0.7	1.4	2.1	2.8	3.6
4 05	30.85	61.69	92.53	123.38	154.22	185.07	215.91	246.76	277.60	1850.7	3701.4	5552.0	7402.7	9253.4
6	.84	.69	.53	.38	.22	.07	.91	.75	.59	0.7	1.3	1.9	2.5	3.2
7	.84	.69	.53	.38	.22	.06	.90	.75	.59	0.6	1.2	1.8	2.4	3.0
8	.84	.68	.53	.37	.22	.06	.90	.74	.58	0.6	1.1	1.6	2.2	2.8
9	.84	.68	.53	.37	.21	.05	.89	.74	.58	0.5	1.1	1.5	2.1	2.6
4 10	30.84	61.68	92.52	123.37	154.21	185.05	215.89	246.73	277.57	1850.5	3701.0	5551.4	7401.9	9252.4
11	.84	.68	.52	.37	.21	.05	.89	.73	.56	0.5	0.9	1.3	1.8	2.2
12	.84	.68	.52	.36	.20	.04	.88	.72	.56	0.4	0.8	1.2	1.6	2.0
13	.84	.68	.52	.36	.20	.04	.88	.72	.55	0.4	0.8	1.0	1.5	1.8
14	.84	.68	.52	.36	.19	.03	.87	.71	.55	0.3	0.7	0.9	1.3	1.6
4 15	30.84	61.68	92.51	123.35	154.19	185.03	215.87	246.71	277.54	1850.3	3700.6	5550.9	7401.2	9251.4
16	.83	.67	.61	.35	.19	.03	.86	.70	.53	0.3	0.5	0.7	1.0	1.2
17	.83	.67	.51	.35	.18	.02	.86	.70	.53	0.2	0.4	0.6	0.8	1.0
18	.83	.67	.51	.35	.18	.02	.85	.69	.52	0.2	0.4	0.4	0.7	0.8
19	.83	.67	.51	.34	.17	.01	.85	.69	.52	0.1	0.3	0.3	0.5	0.6
4 20	30.83	61.67	92.50	123.34	154.17	185.01	215.84	246.68	277.51	1850.1	3700.2	5550.2	7400.3	9250.4
21	.83	.67	.50	.34	.17	.01	.84	.67	.50	0.1	0.1	0.1	0.1	0.2
22	.83	.67	.50	.33	.16	.00	.83	.67	.50	0.0	700.0	50.0	400.0	50.0
23	.83	.67	.50	.33	.16	5.00	.83	.66	.49	50.0	699.9	49.8	399.8	49.8
24	.83	.67	.50	.33	.16	4.99	.82	.66	.49	49.9	9.8	9.7	9.7	9.6
4 25	30.83	61.67	92.49	123.32	154.15	184.99	215.82	246.65	277.48	1849.9	3699.8	5549.6	7399.5	9249.4
26	.83	.66	.49	.32	.15	.99	.81	.64	.47	9.9	9.7	9.5	9.3	9.2
27	.83	.66	.49	.32	.15	.98	.81	.64	.47	9.8	9.6	9.4	9.2	9.0
28	.83	.66	.49	.32	.15	.98	.80	.63	.46	9.8	9.5	9.2	9.0	8.7
29	.83	.66	.49	.31	.14	.97	.80	.63	.46	9.7	9.4	9.1	8.9	8.5
4 30	30.83	61.66	92.48	123.31	154.14	184.97	215.79	246.62	277.45	1849.7	3699.3	5549.0	7398.7	9248.3
31	.83	.66	.48	.31	.14	.97	.79	.61	.44	9.7	9.2	8.9	8.5	8.1
32	.83	.66	.48	.30	.13	.96	.78	.61	.44	9.6	9.1	8.8	8.3	7.9
33	.83	.65	.48	.30	.13	.96	.78	.60	.43	9.6	9.1	8.6	8.2	7.7
34	.83	.65	.48	.30	.12	.95	.77	.60	.42	9.5	9.0	8.5	8.0	7.5
4 35	30.83	61.65	92.47	123.29	154.12	184.95	215.77	246.59	277.41	1849.5	3698.9	5548.4	7397.8	9247.3
36	.82	.65	.47	.29	.12	.94	.76	.58	.41	9.4	8.8	8.3	7.6	7.1
37	.82	.65	.47	.29	.11	.94	.76	.58	.40	9.4	8.7	8.1	7.4	6.9
38	.82	.64	.47	.29	.11	.93	.75	.57	.39	9.3	8.7	8.0	7.3	6.6
39	.82	.64	.46	.28	.10	.93	.75	.57	.38	9.3	8.6	7.8	7.1	6.4
4 40	38.82	61.64	92.46	123.28	154.10	184.92	215.74	246.56	277.38	1849.2	3698.5	5547.7	7396.9	9246.2
41	.82	.64	.46	.28	.10	.92	.74	.56	.37	9.2	8.4	7.6	6.7	6.0
42	.82	.64	.46	.27	.09	.91	.73	.55	.37	9.1	8.3	7.5	6.6	5.8
43	.82	.64	.46	.27	.09	.91	.73	.55	.36	9.1	8.2	7.3	6.4	5.5
44	.82	.64	.45	.27	.09	.90	.72	.54	.36	9.0	8.1	7.2	6.3	5.3
4 45	30.82	61.64	92.45	123.26	154.08	184.90	215.72	246.54	277.35	1849.0	3698.0	5547.1	7396.1	9245.1
46	.81	.63	.45	.26	.08	.90	.71	.53	.34	9.0	8.0	7.0	5.9	4.9
47	.81	.63	.45	.26	.08	.89	.71	.53	.34	8.9	7.9	6.8	5.7	4.7
48	.81	.63	.44	.26	.08	.89	.70	.52	.33	8.9	7.8	6.7	5.6	4.4
49	.81	.63	.44	.25	.07	.88	.70	.52	.33	8.8	7.7	6.5	5.4	4.2
4 50	30.81	61.63	92.44	123.25	154.07	184.88	215.69	246.51	277.32	1848.8	3697.6	5546.4	7395.2	9244.0
51	.81	.63	.44	.25	.07	.88	.69	.50	.31	8.8	7.5	6.3	5.0	3.8
52	.81	.63	.44	.24	.06	.87	.68	.50	.31	8.7	7.4	6.1	4.8	3.5
53	.81	.62	.43	.24	.06	.87	.68	.49	.30	8.7	7.3	6.0	4.7	3.3
54	.81	.62	.43	.24	.05	.86	.67	.48	.29	8.6	7.2	5.8	4.5	3.0
4 55	30.81	61.62	92.43	123.23	154.05	184.86	215.67	246.47	277.28	1848.6	3697.1	5545.7	7394.3	9242.8
56	.81	.62	.43	.23	.05	.85	.66	.47	.28	8.5	7.1	5.6	4.1	2.6
57	.81	.62	.42	.23	.04	.85	.66	.46	.27	8.5	7.0	5.4	3.9	2.4
58	.81	.61	.42	.23	.04	.84	.65	.45	.26	8.4	6.9	5.3	3.7	2.1
59	.81	.61	.42	.22	.03	.84	.65	.45	.26	8.4	6.8	5.1	3.5	1.9
4 60	30.81	61.61	92.42	123.22	154.03	184.83	215.64	246.44	277.25	1848.3	3696.7	5545.0	7393.3	9241.7

Lat.		Latitude 4° to 5°—Meridional arcs.						Latitude 4°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
4	00	30.715			1842.88						
	1	5	1	30.72	.88	1	1 842.9	0	1	1 850.9	
	2	5	2	61.43	.88	2	3 685.8		2	3 701.7	0.1
	3	5	3	92.15	.88	3	5 528.6		3	5 552.6	0.2
	4	5	4	122.86	.88	4	7 371.5		4	7 403.4	0.3
4	05	30.715	5	153.58	1842.88	5	9 214.4	0	5	9 254.3	0.5
	6	5	6	184.29	.88	6	11 057.3		6	11 105.1	0.7
	7	5	7	215.01	.88	7	12 900.2		7	12 956.0	0.9
	8	5	8	245.72	.89	8	14 743.1		8	14 806.9	1.2
	9	5	9	276.44	.89	9	16 585.9		9	16 657.7	1.5
4	10	30.715	10	307.15	1842.89	10	18 428.8	0	10	18 508.6	1.9
	11	5	1	337.87	.89	1	20 271.7		15	27 762.8	4.2
	12	5	2	368.58	.89	2	22 114.6		20	37 017.1	7.5
	13	5	3	399.30	.89	3	23 957.5		25	46 271.4	11.7
	14	5	4	430.01	.89	4	25 800.4		30	55 525.7	16.9
4	15	30.715	15	460.73	1842.89	15	27 643.3	0	35	64 780.0	23.0
	16	5	6	491.44	.89	6	29 486.2		40	74 034.3	30.0
	17	5	7	522.16	.89	7	31 329.0		45	83 288.5	38.0
	18	5	8	552.87	.89	8	33 171.9		50	92 542.8	46.9
	19	5	9	583.59	.89	9	35 014.8		55	101 797.1	56.8
4	20	30.715	20	614.30	1842.89	20	36 857.7	1	00	111 051.4	67.6
	21	5	1	645.02	.90	1	38 700.6		05	120 305.7	79.3
	22	5	2	675.73	.90	2	40 543.5		10	129 559.9	92.0
	23	5	3	706.45	.90	3	42 386.4		15	138 814.2	105.6
	24	5	4	737.16	.90	4	44 229.3		20	148 068.5	120.2
4	25	30.715	25	767.88	1842.90	25	46 072.2	1	25	157 322.7	135.7
	26	5	6	798.59	.90	6	47 915.1		30	166 577.0	152.1
	27	5	7	829.31	.90	7	49 758.0		35	175 831.3	169.5
	28	5	8	860.02	.90	8	51 600.9		40	185 085.5	187.8
	29	5	9	890.74	.90	9	53 443.8		45	194 339.8	207.0
4	30	30.715	30	921.45	1842.90	30	55 286.7	1	50	203 594.0	227.2
	31	5	1	952.17	.90	1	57 129.6		55	212 848.3	248.3
	32	5	2	982.88	.90	2	58 972.5	2	00	222 102	270
	33	5	3	1 013.60	.90	3	60 815.4	3	00	333 153	608
	34	5	4	1 044.31	.90	4	62 658.3	4	00	444 203	1 082
4	35	30.715	35	1 075.03	1842.91	35	64 501.2	5	00	555 253	1 691
	36	5	6	1 105.74	.91	6	66 344.1	6	00	666 302	2 434
	37	5	7	1 136.46	.91	7	68 187.0	7	00	777 350	3 312
	38	5	8	1 167.17	.91	8	70 029.9	8	00	888 397	4 326
	39	5	9	1 197.89	.91	9	71 872.9	9	00	999 442	5 476
4	40	30.715	40	1 228.60	1842.91	40	73 715.8	10	00	1 110 487	6 760
	41	5	1	1 259.32	.91	1	75 558.7	11	00	1 221 529	8 180
	42	5	2	1 290.03	.91	2	77 401.6	12	00	1 332 570	9 735
	43	5	3	1 320.75	.91	3	79 244.5	13	00	1 443 608	11 425
	44	5	4	1 351.46	.91	4	81 087.4	14	00	1 554 644	13 250
4	45	30.715	45	1 382.18	1842.91	45	82 930.3	15	00	1 665 678	15 210
	46	5	6	1 412.89	.92	6	84 773.2	16	00	1 776 710	17 305
	47	5	7	1 443.61	.92	7	86 616.2	17	00	1 887 739	19 536
	48	5	8	1 474.32	.92	8	88 459.1	18	00	1 998 765	21 902
	49	5	9	1 505.04	.92	9	90 302.0	19	00	2 109 789	24 403
4	50	30.715	50	1 535.75	1842.92	50	92 144.9	20	00	2 220 809	27 039
	51	5	1	1 566.47	.92	1	93 987.8	21	00	2 331 825	29 810
	52	5	2	1 597.18	.92	2	95 830.8	22	00	2 442 839	32 717
	53	5	3	1 627.90	.92	3	97 673.7	23	00	2 553 848	35 758
	54	5	4	1 658.61	.92	4	99 516.6	24	00	2 664 854	38 935
4	55	30.715	55	1 689.33	1842.92	55	101 359.5	25	00	2 775 856	42 248
	56	5	6	1 720.04	.93	6	103 202.4	26	00	2 886 854	45 696
	57	5	7	1 750.76	.93	7	105 045.4	27	00	2 997 848	49 278
	58	5	8	1 781.47	.93	8	106 888.3	28	00	3 108 837	52 995
	59	5	9	1 812.19	.93	9	108 731.2	29	00	3 219 821	56 848
4	60	30.715	60	1 842.90	.93	60	110 574.1	30	00	3 330 801	60 835

Latitude 5° to 6°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
5 00	30.81	61.61	92.42	123.22	154.03	184.83	215.64	246.44	277.25	1848.3	3696.7	5545.0	7393.3	9241.7
1	.81	.61	.42	.22	.03	.83	.63	.43	.24	8.3	6.6	4.9	3.1	1.5
2	.81	.61	.41	.21	.02	.82	.63	.43	.24	8.2	6.5	4.7	2.9	1.2
3	.81	.61	.41	.21	.02	.82	.62	.42	.23	8.2	6.4	4.6	2.8	1.0
4	.81	.61	.41	.21	.01	.81	.62	.42	.22	8.1	6.3	4.4	2.6	0.7
5 5	30.81	61.61	92.40	123.20	154.01	184.81	215.61	246.41	277.21	1848.1	3696.2	5544.3	7392.4	9240.5
6	.80	.60	.40	.20	.01	.81	.60	.40	.21	8.1	6.1	4.2	2.2	0.3
7	.80	.60	.40	.20	.00	.80	.60	.40	.20	8.0	6.0	4.0	2.0	40.0
8	.80	.60	.40	.20	4.00	.80	.59	.39	.19	8.0	5.9	3.9	1.8	39.8
9	.80	.60	.39	.19	3.99	.79	.59	.39	.19	7.9	5.8	3.7	1.6	9.5
5 10	30.80	61.60	92.39	123.19	153.99	184.79	215.58	246.38	277.18	1847.9	3695.7	5543.6	7391.4	9239.3
11	.80	.60	.39	.19	.99	.78	.58	.37	.17	7.8	5.6	3.4	1.2	9.0
12	.80	.60	.39	.18	.98	.78	.57	.37	.16	7.8	5.5	3.3	1.0	8.8
13	.80	.59	.38	.18	.98	.77	.57	.36	.16	7.7	5.4	3.1	0.9	8.5
14	.80	.59	.38	.18	.97	.77	.56	.36	.15	7.7	5.3	3.0	0.7	8.3
5 15	30.80	61.59	92.38	123.17	153.97	184.76	215.56	246.35	277.14	1847.6	3695.2	5542.8	7390.5	9238.0
16	.79	.59	.38	.17	.97	.76	.55	.34	.13	7.6	5.1	2.7	0.3	7.8
17	.79	.59	.38	.17	.96	.75	.55	.34	.12	7.5	5.0	2.5	90.1	7.5
18	.79	.58	.37	.17	.96	.75	.54	.33	.12	7.5	4.9	2.4	89.9	7.3
19	.79	.58	.37	.16	.95	.74	.54	.33	.11	7.4	4.8	2.2	9.7	7.0
5 20	30.79	61.58	92.37	123.16	153.95	184.74	215.53	246.32	277.10	1847.4	3694.7	5542.1	7389.5	9236.8
21	.79	.58	.37	.16	.95	.73	.52	.31	.09	7.3	4.6	1.9	9.3	6.5
22	.79	.58	.36	.15	.94	.73	.52	.31	.09	7.3	4.5	1.8	9.1	6.3
23	.79	.57	.36	.15	.94	.72	.51	.30	.08	7.2	4.4	1.6	8.8	6.0
24	.79	.57	.36	.14	.93	.72	.51	.29	.07	7.2	4.3	1.5	8.6	5.8
5 25	30.79	61.57	92.35	123.14	153.93	184.71	215.50	246.28	277.06	1847.1	3694.2	5541.3	7388.4	9235.5
26	.78	.57	.35	.14	.92	.71	.49	.28	.06	7.1	4.1	1.2	8.2	5.3
27	.78	.57	.35	.13	.92	.70	.49	.27	.05	7.0	4.0	1.0	8.0	5.0
28	.78	.56	.35	.13	.91	.70	.48	.26	.04	7.0	3.9	0.9	7.8	4.8
29	.78	.56	.34	.12	.91	.69	.48	.26	.04	6.9	3.8	0.7	7.6	4.5
5 30	30.78	61.56	92.34	123.12	153.90	184.69	215.47	246.25	277.03	1846.9	3693.7	5540.6	7387.4	9234.3
31	.78	.56	.34	.12	.90	.68	.46	.24	.02	6.8	3.6	0.4	7.2	4.0
32	.78	.56	.34	.11	.89	.67	.46	.24	.01	6.7	3.5	0.3	7.0	3.8
33	.78	.55	.33	.11	.89	.67	.45	.23	.01	6.7	3.4	0.1	6.8	3.5
34	.78	.55	.33	.11	.88	.67	.45	.22	7.00	6.7	3.3	40.0	6.6	3.3
5 35	30.78	61.55	92.33	123.10	153.88	184.66	215.44	246.21	276.99	1846.6	3693.2	5539.8	7386.4	9233.0
36	.77	.55	.33	.10	.88	.65	.43	.21	.98	6.5	3.1	9.6	6.2	2.7
37	.77	.55	.33	.10	.87	.65	.43	.20	.97	6.5	3.0	9.5	6.0	2.5
38	.77	.54	.32	.10	.87	.64	.42	.19	.97	6.4	2.9	9.3	5.8	2.2
39	.77	.54	.32	.09	.86	.64	.42	.19	.96	6.4	2.8	9.2	5.6	2.0
5 40	30.77	61.54	92.32	123.09	153.86	184.63	215.41	246.18	276.95	1846.3	3692.7	5539.0	7385.4	9231.7
41	.77	.54	.31	.09	.86	.63	.40	.17	.94	6.3	2.6	8.8	5.2	1.4
42	.77	.54	.31	.08	.85	.62	.40	.17	.93	6.2	2.5	8.7	5.0	1.1
43	.77	.54	.31	.08	.85	.62	.39	.16	.93	6.2	2.3	8.5	4.7	0.9
44	.77	.54	.31	.07	.84	.61	.38	.15	.92	6.1	2.2	8.4	4.5	0.6
5 45	30.77	61.54	92.30	123.07	153.84	184.61	215.37	246.14	276.91	1846.1	3692.1	5538.2	7384.3	9230.3
46	.76	.53	.30	.07	.84	.60	.37	.14	.90	6.0	2.0	8.0	4.1	30.0
47	.76	.53	.30	.06	.83	.60	.36	.13	.89	6.0	1.9	7.9	3.9	29.8
48	.76	.53	.30	.06	.83	.59	.35	.12	.89	5.9	1.8	7.7	3.7	9.5
49	.76	.53	.29	.05	.82	.59	.35	.12	.88	5.9	1.7	7.6	3.5	9.3
5 50	30.76	61.53	92.29	123.05	153.82	184.58	215.34	246.11	276.87	1845.8	3691.6	5537.4	7383.2	9229.0
51	.76	.53	.29	.05	.82	.57	.33	.10	.86	5.7	1.5	7.2	3.0	8.7
52	.76	.53	.28	.04	.81	.57	.33	.09	.85	5.7	1.4	7.0	2.8	8.4
53	.76	.52	.28	.04	.81	.56	.32	.09	.85	5.6	1.2	6.9	2.5	8.2
54	.76	.52	.28	.04	.80	.56	.32	.08	.84	5.6	1.1	6.7	2.3	7.9
5 55	30.76	61.52	92.27	123.03	153.80	184.55	215.31	246.07	276.83	1845.5	3691.0	5536.5	7382.1	9227.6
56	.75	.52	.27	.03	.79	.54	.30	.06	.82	5.4	0.9	6.3	1.9	7.3
57	.75	.52	.27	.03	.79	.54	.30	.05	.81	5.4	0.8	6.2	1.7	7.0
58	.75	.51	.27	.03	.78	.53	.29	.05	.81	5.3	0.7	6.0	1.4	6.8
59	.75	.51	.26	.02	.78	.53	.29	.04	.80	5.3	0.6	5.9	1.2	6.5
5 60	30.75	61.51	92.26	123.02	153.77	184.52	215.28	246.03	276.79	1845.2	3690.5	5535.7	7381.0	9226.2

Lat.	Latitude 5° to 6°—Meridional arcs.						Latitude 5°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
5 00	30.715			1842.93					
1	5	1	30.72	.93	1	1 842.9	0 1	1 848.3	
2	6	2	61.43	.93	2	3 685.9	2	3 696.7	0.1
3	6	3	92.15	.93	3	5 528.8	3	5 545.0	0.2
4	6	4	122.86	.93	4	7 371.7	4	7 393.3	0.4
5 05	30.716	5	153.58	1842.93	5	9 214.7	0 5	9 241.7	0.6
6	6	6	184.30	.93	6	11 057.6	6	11 090.0	0.8
7	6	7	215.01	.94	7	12 900.5	7	12 938.3	1.1
8	6	8	245.73	.94	8	14 743.5	8	14 786.7	1.5
9	6	9	276.44	.94	9	16 586.4	9	16 635.0	1.9
5 10	30.716	10	307.16	1842.94	10	18 429.3	0 10	18 483.3	2.3
11	6	1	337.88	.94	1	20 272.3	15	27 725.0	5.3
12	6	2	368.59	.94	2	22 115.2	20	36 966.6	9.4
13	6	3	399.31	.94	3	23 958.2	25	46 208.3	14.6
14	6	4	430.02	.94	4	25 801.1	30	55 449.9	21.1
5 15	30.716	15	460.74	1842.94	15	27 644.1	0 35	64 691.6	28.7
16	6	6	491.46	.94	6	29 487.0	40	73 933.3	37.5
17	6	7	522.17	.95	7	31 329.9	45	83 174.9	47.4
18	6	8	552.89	.95	8	33 172.9	50	92 416.6	58.6
19	6	9	583.60	.95	9	35 015.8	55	101 658.2	70.9
5 20	30.716	20	614.32	1842.85	20	36 858.8	1 00	110 899.9	84.4
21	6	1	645.04	.95	1	38 701.7	05	120 141.5	99.0
22	6	2	675.75	.95	2	40 544.7	10	129 383.2	114.8
23	6	3	706.47	.95	3	42 387.6	15	138 624.8	131.8
24	6	4	737.18	.95	4	44 230.6	20	147 866.4	150.0
5 25	30.716	25	767.90	1842.95	25	46 073.5	1 25	157 108.0	169.3
26	6	6	798.62	.95	6	47 916.5	30	166 349.7	189.8
27	6	7	829.33	.96	7	49 759.5	35	175 591.3	211.5
28	6	8	860.05	.96	8	51 602.4	40	184 832.9	234.3
29	6	9	890.76	.96	9	53 445.4	45	194 074.5	258.3
5 30	30.716	30	921.48	1842.96	30	55 288.3	1 50	203 316.2	283.5
31	6	1	952.20	.96	1	57 131.3	55	212 557.8	309.9
32	6	2	982.91	.96	2	58 974.3	2 00	221 799	337
33	6	3	1 013.63	.96	3	60 817.2	3 00	332 699	759
34	6	4	1 044.34	.96	4	62 660.2	4 00	443 597	1 349
5 35	30.716	35	1 075.06	1842.96	35	64 503.1	5 00	554 494	2 108
36	6	6	1 105.78	.97	6	66 346.1	6 00	665 390	3 036
37	6	7	1 136.49	.97	7	68 189.1	7 00	776 284	4 133
38	6	8	1 167.21	.97	8	70 032.0	8 00	887 177	5 398
39	6	9	1 197.92	.97	9	71 875.0	9 00	998 068	6 832
5 40	30.716	40	1 228.64	1842.97	40	73 718.0	10 00	1 108 956	8 435
41	6	1	1 259.36	.97	1	75 560.9	11 00	1 219 842	10 206
42	6	2	1 290.07	.97	2	77 403.9	12 00	1 330 725	12 146
43	6	3	1 320.79	.97	3	79 246.9	13 00	1 441 604	14 255
44	6	4	1 351.50	.97	4	81 089.9	14 00	1 552 481	16 532
5 45	30.716	45	1 382.22	1842.97	45	82 932.9	15 00	1 663 354	18 977
46	6	6	1 412.94	.98	6	84 775.8	16 00	1 774 223	21 592
47	6	7	1 443.65	.98	7	86 618.8	17 00	1 885 088	24 376
48	6	8	1 474.37	.98	8	88 461.8	18 00	1 995 948	27 328
49	6	9	1 505.08	.98	9	90 304.8	19 00	2 106 804	30 448
5 50	30.716	50	1 535.80	1842.98	50	92 147.7	20 00	2 217 655	33 737
51	6	1	1 566.52	.98	1	93 990.7	21 00	2 328 502	37 195
52	6	2	1 597.23	.98	2	95 833.7	22 00	2 439 342	40 821
53	6	3	1 627.95	.98	3	97 676.7	23 00	2 550 177	44 616
54	6	4	1 658.66	.98	4	99 519.7	24 00	2 661 006	48 579
5 55	30.716	55	1 689.38	1842.98	55	101 362.7	25 00	2 771 829	52 711
56	6	6	1 720.10	.99	6	103 205.6	26 00	2 882 645	57 013
57	6	7	1 750.81	.99	7	105 048.6	27 00	2 993 455	61 483
58	6	8	1 781.53	.99	8	106 891.6	28 00	3 104 259	66 120
59	6	9	1 812.24	.99	9	108 734.6	29 00	3 215 055	70 926
5 60	30.716	60	1 842.96	1842.99	60	110 577.6	30 00	3 325 844	75 900

Latitude 6° to 7°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
6 00	30.75	61.51	92.26	123.02	153.77	184.52	215.28	246.03	276.79	1845.2	3690.5	5535.7	7381.0	9226.2
1	.75	.51	.26	.02	.77	.52	.27	.02	.78	5.2	0.4	5.5	0.8	5.9
2	.75	.51	.26	.01	.76	.51	.27	.02	.77	5.1	0.3	5.4	0.6	5.6
3	.75	.50	.25	.01	.76	.51	.26	.01	.76	5.1	0.1	5.2	0.3	5.4
4	.75	.50	.25	.00	.75	.50	.25	6.00	.75	5.0	90.0	5.1	80.1	5.1
6 05	30.75	61.50	92.25	123.00	153.75	184.50	215.24	245.99	276.74	1845.0	3689.9	5534.9	7379.9	9224.8
6	.74	.50	.24	.00	.74	.49	.24	.99	.74	4.9	9.8	4.7	9.7	4.5
7	.74	.50	.24	3.00	.74	.49	.23	.98	.73	4.9	9.7	4.5	9.4	4.2
8	.74	.49	.24	2.99	.73	.48	.22	.97	.72	4.8	9.6	4.4	9.2	4.0
9	.74	.49	.24	.99	.73	.48	.22	.97	.71	4.8	9.5	4.2	8.9	3.7
6 10	30.74	61.49	92.23	122.98	153.72	184.47	215.21	245.96	276.70	1844.7	3689.4	5534.0	7378.7	9223.4
11	.74	.49	.23	.98	.72	.46	.20	.95	.69	4.6	9.3	3.8	8.5	3.1
12	.74	.49	.23	.97	.71	.46	.20	.94	.68	4.6	9.2	3.7	8.3	2.8
13	.74	.48	.22	.97	.71	.45	.19	.94	.67	4.5	9.0	3.5	8.0	2.5
14	.74	.48	.22	.96	.70	.45	.18	.93	.66	4.5	8.9	3.4	7.8	2.2
6 15	30.74	61.48	92.22	122.96	153.70	184.44	215.17	245.92	276.65	1844.4	3688.8	5533.2	7377.6	9221.9
16	.73	.48	.22	.96	.69	.43	.17	.91	.65	4.3	8.7	3.0	7.4	1.6
17	.73	.48	.21	.95	.69	.43	.16	.90	.64	4.3	8.6	2.8	7.1	1.3
18	.73	.47	.21	.95	.68	.42	.15	.90	.63	4.2	8.4	2.7	6.9	1.1
19	.73	.47	.21	.94	.68	.42	.15	.89	.62	4.2	8.3	2.5	6.6	0.8
6 20	30.73	61.47	92.20	122.94	153.67	184.41	215.14	245.88	276.61	1844.1	3688.2	5532.3	7376.4	9220.5
21	.73	.47	.20	.94	.67	.40	.13	.87	.60	4.0	8.1	2.1	6.2	20.2
22	.73	.47	.20	.93	.66	.40	.13	.86	.59	4.0	8.0	1.9	5.9	19.9
23	.73	.46	.20	.93	.66	.39	.12	.86	.58	3.9	7.8	1.8	5.7	9.6
24	.73	.46	.19	.92	.65	.39	.11	.85	.57	3.9	7.7	1.6	5.4	9.3
6 25	30.73	61.46	92.19	122.92	153.65	184.38	215.10	245.84	276.56	1843.8	3687.6	5531.4	7375.2	9219.0
26	.72	.46	.19	.92	.64	.37	.10	.83	.56	3.7	7.5	1.2	5.0	8.7
27	.72	.46	.18	.91	.64	.37	.09	.82	.55	3.7	7.4	1.0	4.7	8.4
28	.72	.45	.18	.91	.63	.36	.08	.82	.54	3.6	7.2	0.9	4.5	8.1
29	.72	.45	.18	.90	.63	.36	.08	.81	.53	3.6	7.1	0.7	4.2	7.8
6 30	30.72	61.45	92.17	122.90	153.62	184.35	215.07	245.80	276.52	1843.5	3687.0	5530.5	7374.0	9217.5
31	.72	.45	.17	.90	.62	.34	.06	.79	.51	3.4	6.9	0.3	3.8	7.2
32	.72	.45	.17	.89	.61	.34	.06	.78	.50	3.4	6.8	0.1	3.5	6.9
33	.72	.44	.16	.89	.61	.33	.05	.78	.49	3.3	6.6	30.0	3.3	6.5
34	.72	.44	.16	.88	.60	.33	.04	.77	.48	3.3	6.5	29.8	3.0	6.2
6 35	30.72	61.44	92.16	122.88	153.60	184.32	215.03	245.76	276.47	1843.2	3686.4	5529.6	7372.8	9215.9
36	.71	.44	.16	.88	.59	.31	.03	.75	.47	3.1	6.3	9.4	2.6	5.6
37	.71	.44	.15	.87	.59	.31	.02	.74	.46	3.1	6.2	9.2	2.3	5.3
38	.71	.43	.15	.87	.58	.30	.01	.74	.45	3.0	6.0	9.1	2.1	5.0
39	.71	.43	.15	.86	.58	.30	.01	.73	.44	3.0	5.9	8.9	1.8	4.7
6 40	30.71	61.43	92.14	122.86	153.57	184.29	215.00	245.72	276.43	1842.9	3685.8	5528.7	7371.6	9214.4
41	.71	.43	.14	.86	.57	.28	4.99	.71	.42	2.8	5.7	8.5	1.3	4.1
42	.71	.43	.14	.85	.56	.28	.99	.70	.41	2.8	5.5	8.3	1.1	3.8
43	.71	.42	.13	.85	.56	.27	.98	.69	.40	2.7	5.4	8.1	0.8	3.4
44	.71	.42	.13	.84	.55	.27	.97	.68	.39	2.7	5.2	7.9	0.6	3.1
6 45	30.71	61.42	92.13	122.84	153.55	184.26	214.96	245.67	276.38	1842.6	3685.1	5527.7	7370.3	9212.8
46	.70	.42	.12	.84	.54	.25	.96	.67	.38	2.5	5.0	7.5	70.0	2.5
47	.70	.42	.12	.83	.54	.25	.95	.66	.37	2.5	4.9	7.3	69.8	2.2
48	.70	.41	.12	.83	.53	.24	.94	.65	.36	2.4	4.7	7.2	9.5	1.9
49	.70	.41	.12	.82	.53	.24	.94	.64	.35	2.4	4.6	7.0	9.3	1.6
6 50	30.70	61.41	92.11	122.82	153.52	184.23	214.93	245.63	276.34	1842.3	3684.5	5526.8	7369.0	9211.3
51	.70	.41	.11	.82	.52	.22	.92	.62	.33	2.2	4.4	6.6	8.7	1.0
52	.70	.41	.11	.81	.51	.21	.91	.61	.32	2.1	4.3	6.4	8.5	0.6
53	.70	.40	.10	.81	.51	.21	.91	.61	.31	2.1	4.1	6.2	8.2	10.3
54	.70	.40	.10	.80	.50	.20	.90	.60	.30	2.0	4.0	6.0	8.0	09.9
6 55	30.70	61.40	92.10	122.80	153.50	184.19	214.89	245.59	276.29	1841.9	3683.9	5525.8	7367.7	9209.6
56	.69	.40	.09	.79	.49	.19	.88	.58	.28	1.9	3.8	5.6	7.4	9.3
57	.69	.40	.09	.79	.49	.18	.87	.57	.27	1.8	3.6	5.4	7.2	9.0
58	.69	.39	.09	.78	.48	.17	.87	.57	.26	1.7	3.5	5.2	6.9	8.6
59	.69	.39	.08	.78	.48	.17	.86	.56	.25	1.7	3.3	5.0	6.7	8.3
6 60	30.69	61.39	92.08	122.77	153.47	184.16	214.85	245.55	276.24	1841.6	3683.2	5524.8	7366.4	9208.0

Lat.	Latitude 6° to 7°—Meridional arcs.						Latitude 6°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
6 00	30.716			1842.99					
1	7	1	30.72	.99	1	1 843.0	0 1	1 845.3	
2	7	2	61.43	.99	2	3 686.0	2	3 690.5	0.1
3	7	3	92.15	.99	3	5 529.0	3	5 535.8	0.2
4	7	4	122.87	.99	4	7 372.0	4	7 381.0	0.4
6 05	30.717	5	153.59	1843.00	5	9 215.0	0 5	9 226.3	0.7
6	7	6	184.30	.00	6	11 058.0	6	11 071.5	1.0
7	7	7	215.02	.00	7	12 901.0	7	12 916.7	1.4
8	7	8	245.74	.00	8	14 744.0	8	14 762.0	1.8
9	7	9	276.45	.00	9	16 587.0	9	16 607.2	2.3
6 10	30.717	10	307.17	1843.00	10	18 430.0	0 10	18 452.5	2.8
11	7	1	337.89	.00	1	20 273.0	15	27 678.8	6.3
12	7	2	368.61	.00	2	22 116.0	20	36 905.0	11.2
13	7	3	399.32	.00	3	23 959.0	25	46 131.2	17.5
14	7	4	430.04	.01	4	25 802.0	30	55 357.5	25.3
6 15	30.717	15	460.76	1843.01	15	27 645.0	0 35	64 583.8	34.4
16	7	6	491.47	.01	6	29 488.0	40	73 810.0	44.9
17	7	7	522.19	.01	7	31 331.0	45	83 036.2	56.8
18	7	8	552.91	.01	8	33 174.0	50	92 262.5	70.1
19	7	9	583.63	.01	9	35 017.0	55	101 488.7	84.9
6 20	30.717	20	614.34	1843.01	20	36 860.0	1 00	110 714.9	101.0
21	7	1	645.06	.01	1	38 703.1	05	119 941.2	118.5
22	7	2	675.78	.02	2	40 546.1	10	129 167.4	137.5
23	7	3	706.49	.02	3	42 389.1	15	138 393.6	157.8
24	7	4	737.21	.02	4	44 232.1	20	147 619.9	179.5
6 25	30.717	25	767.93	1843.02	25	46 075.1	1 25	156 846.1	202.7
26	7	6	798.65	.02	6	47 918.2	30	166 072.3	227.2
27	7	7	829.36	.02	7	49 761.2	35	175 298.5	253.2
28	7	8	860.08	.02	8	51 604.2	40	184 524.7	280.5
29	7	9	890.80	.02	9	53 447.2	45	193 750.9	309.3
6 30	30.717	30	921.51	1843.03	30	55 290.3	1 50	202 977.1	339.4
31	7	1	952.23	.03	1	57 133.3	55	212 203.3	371.0
32	7	2	982.95	.03	2	58 976.3	2 00	221 429	404
33	7	3	1 013.67	.03	3	60 819.4	3 00	332 143	909
34	7	4	1 044.38	.03	4	62 662.4	4 00	442 856	1 616
6 35	30.717	35	1 075.10	1843.03	35	64 505.4	5 00	553 567	2 525
36	7	6	1 105.82	.03	6	66 348.4	6 00	664 277	3 636
37	7	7	1 136.54	.03	7	68 191.5	7 00	774 984	4 949
38	7	8	1 167.25	.04	8	70 034.5	8 00	885 689	6 464
39	7	9	1 197.97	.04	9	71 877.6	9 00	996 390	8 180
6 40	30.717	40	1 228.69	1843.04	40	73 720.6	10 00	1 107 088	10 099
41	7	1	1 259.40	.04	1	75 563.6	11 00	1 217 783	12 220
42	7	2	1 290.12	.04	2	77 406.7	12 00	1 328 474	14 543
43	7	3	1 320.84	.04	3	79 249.7	13 00	1 439 160	17 067
44	7	4	1 351.56	.04	4	81 092.8	14 00	1 549 841	19 793
6 45	30.717	45	1 382.27	1843.04	45	82 935.8	15 00	1 660 518	22 721
46	7	6	1 412.97	.05	6	84 778.9	16 00	1 771 189	25 852
47	7	7	1 443.71	.05	7	86 621.9	17 00	1 881 854	29 185
48	7	8	1 474.42	.05	8	88 464.9	18 00	1 992 512	32 719
49	7	9	1 505.14	.05	9	90 308.0	19 00	2 103 164	36 454
6 50	30.718	50	1 535.86	1843.05	50	92 151.1	20 00	2 213 809	40 392
51	8	1	1 566.57	.05	1	93 994.1	21 00	2 324 446	44 532
52	8	2	1 597.29	.05	2	95 837.2	22 00	2 435 076	48 874
53	8	3	1 628.01	.05	3	97 680.2	23 00	2 545 698	53 418
54	8	4	1 658.72	.06	4	99 523.3	24 00	2 656 311	58 163
6 55	30.718	55	1 689.44	1843.06	55	101 366.3	25 00	2 766 915	63 109
56	8	6	1 720.16	.06	6	103 209.4	26 00	2 877 511	68 257
57	8	7	1 750.88	.06	7	105 052.4	27 00	2 988 097	73 607
58	8	8	1 781.59	.06	8	106 895.5	28 00	3 098 672	79 160
59	8	9	1 812.31	.06	9	108 738.6	29 00	3 209 237	84 915
6 60	30.718	60	1 843.03	1843.06	60	110 581.6	30 00	3 319 792	90 871

Latitude 7° to 8°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
7 00	30.69	61.39	92.08	122.77	153.47	184.16	214.85	245.55	276.24	1841.6	3683.2	5524.8	7366.4	9208.0
1	.69	.39	.08	.77	.46	.15	.84	.54	.23	1.5	3.1	4.6	6.1	7.7
2	.69	.39	.07	.76	.46	.15	.84	.53	.22	1.5	3.0	4.4	5.9	7.4
3	.69	.38	.07	.76	.45	.14	.83	.52	.21	1.4	2.8	4.2	5.6	7.0
4	.69	.38	.07	.75	.45	.13	.82	.51	.20	1.3	2.7	4.0	5.4	6.7
7 05	30.69	61.38	92.06	122.75	153.44	184.13	214.81	245.50	276.19	1841.3	3682.6	5523.8	7365.1	9206.4
6	.68	.38	.06	.75	.43	.12	.81	.50	.18	1.2	2.5	3.6	4.8	6.1
7	.68	.38	.06	.74	.43	.11	.80	.49	.17	1.1	2.3	3.4	4.6	5.7
8	.68	.37	.05	.74	.42	.11	.79	.48	.16	1.1	2.2	3.2	4.3	5.4
9	.68	.37	.05	.73	.42	.10	.79	.47	.15	1.0	2.0	3.0	4.1	5.0
7 10	30.68	61.37	92.05	122.73	153.41	184.09	214.78	245.46	276.14	1840.9	3681.9	5522.8	7363.8	9204.7
11	.68	.37	.04	.73	.41	.08	.77	.45	.13	0.8	1.8	2.6	3.5	4.4
12	.68	.36	.04	.72	.40	.08	.76	.44	.12	0.8	1.6	2.4	3.2	4.0
13	.68	.36	.04	.72	.40	.07	.76	.43	.11	0.7	1.4	2.2	3.0	3.7
14	.68	.36	.03	.71	.39	.07	.75	.42	.10	0.7	1.3	2.0	2.7	3.3
7 15	30.68	61.35	92.03	122.71	153.39	184.06	214.74	245.41	276.09	1840.6	3681.2	5521.8	7362.4	9203.0
16	.67	.35	.03	.70	.38	.05	.73	.41	.08	0.5	1.1	1.6	2.1	2.7
17	.67	.35	.02	.70	.38	.05	.72	.40	.07	0.5	0.9	1.4	1.9	2.4
18	.67	.35	.02	.69	.37	.04	.72	.39	.06	0.4	0.8	1.2	1.6	2.0
19	.67	.34	.02	.69	.37	.04	.71	.38	.05	0.4	0.6	1.0	1.4	1.7
7 20	30.67	61.34	92.01	122.68	153.36	184.03	214.70	245.37	276.04	1840.3	3680.5	5520.8	7361.1	9201.4
21	.67	.34	.01	.68	.35	.02	.69	.36	.03	0.2	0.4	0.6	0.8	1.0
22	.67	.34	.01	.67	.35	.01	.68	.35	.02	0.1	0.2	0.4	0.5	0.7
23	.67	.33	.00	.67	.34	.01	.68	.34	.01	0.1	80.1	0.2	0.3	0.3
24	.67	.33	.00	.66	.34	4.00	.67	.33	6.00	40.0	79.9	20.0	60.0	200.0
7 25	30.67	61.33	92.00	122.66	153.33	183.99	214.66	245.32	275.99	1839.9	3679.8	5519.8	7359.7	9199.6
26	.66	.33	1.99	.66	.32	.99	.65	.32	.98	9.9	9.7	9.6	9.4	9.3
27	.66	.33	.99	.65	.32	.98	.64	.31	.97	9.8	9.6	9.4	9.1	8.9
28	.66	.32	.99	.65	.31	.97	.64	.30	.96	9.7	9.4	9.1	8.9	8.6
29	.66	.32	.98	.64	.31	.97	.63	.29	.95	9.7	9.3	8.9	8.6	8.2
7 30	30.66	61.32	91.98	122.64	153.30	183.96	214.62	245.28	275.94	1839.6	3679.2	5518.7	7358.3	9197.9
31	.66	.32	.98	.64	.29	.95	.61	.27	.93	9.5	9.0	8.5	8.0	7.5
32	.66	.32	.97	.63	.29	.94	.60	.26	.92	9.4	8.9	8.3	7.7	7.2
33	.66	.31	.97	.63	.28	.94	.59	.25	.91	9.4	8.7	8.1	7.5	6.8
34	.66	.31	.96	.62	.28	.93	.58	.24	.90	9.3	8.6	7.9	7.2	6.5
7 35	30.66	61.31	91.96	122.62	153.27	183.92	214.57	245.23	275.88	1839.2	3678.4	5517.7	7356.9	9196.1
36	.65	.31	.96	.61	.26	.92	.57	.22	.87	9.2	8.3	7.5	6.6	5.8
37	.65	.31	.95	.61	.26	.91	.56	.21	.86	9.1	8.1	7.3	6.3	5.4
38	.65	.30	.95	.60	.25	.90	.55	.20	.85	9.0	8.0	7.0	6.1	5.1
39	.65	.30	.95	.60	.25	.90	.54	.19	.84	9.0	7.8	6.8	5.8	4.7
7 40	30.65	61.30	91.94	122.59	153.24	183.89	214.53	245.18	275.83	1838.9	3677.7	5516.6	7355.5	9194.4
41	.65	.30	.94	.59	.23	.88	.52	.17	.82	8.8	7.6	6.4	5.2	4.0
42	.65	.29	.94	.58	.23	.87	.51	.16	.81	8.7	7.4	6.2	4.9	3.6
43	.65	.29	.93	.58	.22	.87	.51	.15	.80	8.7	7.3	5.9	4.6	3.3
44	.65	.29	.93	.57	.22	.86	.50	.14	.79	8.6	7.1	5.7	4.3	2.9
7 45	30.65	61.28	91.92	122.57	153.21	183.85	214.49	245.13	275.77	1838.5	3677.0	5515.5	7354.0	9192.5
46	.64	.28	.92	.56	.20	.84	.48	.13	.76	8.4	6.9	5.3	3.7	2.1
47	.64	.28	.92	.56	.20	.83	.47	.12	.75	8.3	6.7	5.1	3.4	1.8
48	.64	.28	.91	.55	.19	.83	.47	.11	.74	8.3	6.6	4.8	3.2	1.4
49	.64	.27	.91	.55	.19	.82	.46	.10	.73	8.2	6.4	4.6	2.9	1.1
7 50	30.64	61.27	91.91	122.54	153.18	183.81	214.45	245.09	275.72	1838.1	3676.3	5514.4	7352.6	9190.7
51	.64	.27	.90	.54	.17	.80	.44	.08	.71	8.0	6.1	4.2	2.3	0.3
52	.64	.27	.90	.53	.17	.80	.43	.07	.70	8.0	6.0	4.0	2.0	90.0
53	.63	.26	.90	.53	.16	.79	.42	.06	.69	7.9	5.8	3.7	1.7	89.6
54	.63	.26	.89	.52	.16	.79	.41	.05	.68	7.9	5.7	3.5	1.4	9.3
7 55	30.63	61.26	91.89	122.52	153.15	183.78	214.40	245.04	275.66	1837.8	3675.5	5513.3	7351.1	9188.9
56	.63	.26	.89	.51	.14	.77	.40	.03	.65	7.7	5.4	3.1	0.8	8.5
57	.63	.26	.88	.51	.14	.76	.39	.02	.64	7.6	5.2	2.9	0.5	8.1
58	.62	.25	.88	.50	.13	.76	.38	.01	.63	7.6	5.1	2.6	50.2	7.8
59	.62	.25	.87	.50	.13	.75	.37	5.00	.62	7.5	4.9	2.4	49.9	7.4
7 60	30.62	61.25	91.87	122.49	153.12	183.74	214.36	244.99	275.61	1837.4	3674.8	5512.2	7349.6	9187.0

Lat.		Latitude 7° to 8°—Meridional arcs.						Latitude 7°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
7	00	30.718			1843.06						
	1	8	1	30.72	.07	1	1 843.1	0	1	1 841.6	
	2	8	2	61.44	.07	2	3 686.1		2	3 683.2	0.1
	3	8	3	92.16	.07	3	5 529.2		3	5 524.8	0.3
	4	8	4	122.87	.07	4	7 372.3		4	7 366.4	0.5
7	05	30.718	5	153.59	1843.07	5	9 215.3	0	5	9 208.0	0.8
	6	8	6	184.31	.07	6	11 058.4		6	11 049.7	1.2
	7	8	7	215.03	.07	7	12 901.5		7	12 891.3	1.6
	8	8	8	245.75	.08	8	14 744.6		8	14 732.9	2.1
	9	8	9	276.47	.08	9	16 587.6		9	16 574.5	2.6
7	10	30.718	10	307.18	1843.08	10	18 430.7	0	10	18 416.1	3.3
	11	8	1	337.90	.08	1	20 273.8		15	27 624.1	7.3
	12	8	2	368.62	.08	2	22 116.9		20	36 832.1	13.1
	13	8	3	399.34	.08	3	23 960.0		25	46 040.2	20.4
	14	8	4	430.06	.08	4	25 803.0		30	55 248.2	29.4
7	15	30.718	15	460.78	1843.09	15	27 646.1	0	35	64 456.2	40.0
	16	8	6	491.49	.09	6	29 489.2		40	73 664.3	52.2
	17	8	7	522.21	.09	7	31 332.3		45	82 872.3	66.1
	18	8	8	552.93	.09	8	33 175.4		50	92 080.3	81.6
	19	8	9	583.65	.09	9	35 018.5		55	101 288.3	98.7
7	20	30.718	20	614.37	1843.09	20	36 861.6	1	00	110 496.4	117.5
	21	8	1	645.09	.09	1	38 704.7		05	119 704.4	137.9
	22	8	2	675.81	.10	2	40 547.8		10	128 912.4	160.0
	23	8	3	706.52	.10	3	42 390.9		15	138 120.4	183.6
	24	8	4	737.24	.10	4	44 234.0		20	147 328.4	208.9
7	25	30.718	25	767.96	1843.10	25	46 077.1	1	25	156 536.4	235.8
	26	8	6	798.68	.10	6	47 920.2		30	165 744.4	264.4
	27	8	7	829.40	.10	7	49 763.3		35	174 952.4	294.6
	28	8	8	860.12	.10	8	51 606.4		40	184 160.4	326.4
	29	8	9	890.83	.10	9	53 449.5		45	193 368.4	359.9
7	30	30.718	30	921.55	1843.11	30	55 292.6	1	50	202 576.3	395.0
	31	8	1	952.27	.11	1	57 135.7		55	211 784.3	431.7
	32	8	2	982.99	.11	2	58 978.8	2	00	220 992	470
	33	8	3	1 013.71	.11	3	60 821.9	3	00	331 487	1 058
	34	8	4	1 044.43	.11	4	62 665.0	4	00	441 981	1 880
7	35	30.719	35	1 075.15	1843.11	35	64 508.1	5	00	552 472	2 938
	36	9	6	1 105.86	.11	6	66 351.2	6	00	662 961	4 231
	37	9	7	1 136.58	.11	7	68 194.4	7	00	773 447	5 758
	38	9	8	1 167.30	.11	8	70 037.5	8	00	883 929	7 521
	39	9	9	1 198.02	.12	9	71 880.6	9	00	994 407	9 519
7	40	30.719	40	1 228.74	1843.12	40	73 723.7	10	00	1 104 881	11 751
	41	9	1	1 259.46	.12	1	75 566.8	11	00	1 215 350	14 218
	42	9	2	1 290.17	.12	2	77 409.9	12	00	1 325 813	16 921
	43	9	3	1 320.89	.12	3	79 253.1	13	00	1 436 271	19 859
	44	9	4	1 351.61	.12	4	81 096.2	14	00	1 546 722	23 031
7	45	30.719	45	1 382.33	1843.13	45	82 939.3	15	00	1 657 166	26 438
	46	9	6	1 413.05	.13	6	84 782.4	16	00	1 767 602	30 080
	47	9	7	1 443.77	.13	7	86 625.6	17	00	1 878 030	33 958
	48	9	8	1 474.48	.13	8	88 468.7	18	00	1 988 450	38 070
	49	9	9	1 505.20	.13	9	90 311.8	19	00	2 098 861	42 417
7	50	30.719	50	1 535.92	1843.13	50	92 155.0	20	00	2 209 263	46 999
	51	9	1	1 566.64	.13	1	93 998.1	21	00	2 319 654	51 815
	52	9	2	1 597.36	.14	2	95 841.2	22	00	2 430 035	56 866
	53	9	3	1 628.08	.14	3	97 684.4	23	00	2 540 405	62 152
	54	9	4	1 658.80	.14	4	99 527.5	24	00	2 650 764	67 673
7	55	30.719	55	1 689.51	1843.14	55	101 370.7	25	00	2 761 111	73 429
	56	9	6	1 720.23	.14	6	103 213.8	26	00	2 871 444	79 420
	57	9	7	1 750.95	.14	7	105 056.9	27	00	2 981 766	85 644
	58	9	8	1 781.67	.15	8	106 900.1	28	00	3 092 073	92 103
	59	9	9	1 812.39	.15	9	108 743.2	29	00	3 202 367	98 797
7	60	30.719	60	1 843.11	1843.15	60	110 586.4	30	00	3 312 646	105 727

Latitude 8° to 9°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
8 00	30.62	61.25	91.87	122.49	153.12	183.74	214.36	244.99	275.61	1837.4	3674.8	5512.2	7349.6	9187.0
1	.62	.25	.87	.49	.11	.73	.35	.98	.60	7.3	4.7	2.0	9.3	6.6
2	.62	.24	.86	.48	.11	.72	.34	.97	.59	7.2	4.5	1.8	9.0	6.2
3	.62	.24	.86	.48	.10	.72	.34	.96	.58	7.2	4.4	1.5	8.7	5.9
4	.62	.24	.85	.47	.09	.71	.33	.95	.57	7.1	4.2	1.3	8.4	5.5
8 05	30.62	61.23	91.85	122.47	153.08	183.70	214.32	244.94	275.55	1837.0	3674.1	5511.1	7348.1	9185.1
6	.61	.23	.85	.46	.08	.69	.31	.93	.54	6.9	3.9	0.9	7.8	4.7
7	.61	.23	.84	.46	.07	.69	.30	.92	.53	6.9	3.8	0.7	7.5	4.4
8	.61	.23	.84	.45	.06	.68	.29	.91	.52	6.8	3.6	0.4	7.2	4.0
9	.61	.22	.84	.45	.06	.68	.29	.90	.51	6.8	3.5	0.2	6.9	3.7
8 10	30.61	61.22	91.83	122.44	153.05	183.67	214.28	244.89	275.50	1836.7	3673.3	5510.0	7346.6	9183.3
11	.61	.22	.83	.44	.04	.66	.27	.88	.49	6.6	3.1	09.8	6.3	2.9
12	.61	.22	.82	.43	.04	.65	.26	.87	.48	6.5	3.0	9.5	6.0	2.5
13	.61	.21	.82	.43	.03	.65	.25	.86	.46	6.5	2.8	9.3	5.7	2.1
14	.61	.21	.82	.42	.03	.64	.24	.85	.45	6.4	2.7	9.0	5.4	1.7
8 15	30.61	61.21	91.81	122.42	153.02	183.63	214.23	244.83	275.44	1836.3	3672.5	5508.8	7345.1	9181.3
16	.60	.21	.81	.41	.01	.62	.23	.82	.43	6.2	2.4	8.6	4.8	0.9
17	.60	.21	.80	.41	.01	.61	.22	.81	.42	6.1	2.2	8.4	4.5	0.5
18	.60	.20	.80	.40	.00	.61	.21	.80	.40	6.1	2.1	8.1	4.1	80.2
19	.60	.20	.80	.40	3.00	.60	.20	.79	.39	6.0	1.9	7.9	3.8	79.8
8 20	30.60	61.20	91.79	122.39	152.99	183.59	214.19	244.78	275.38	1835.9	3671.8	5507.7	7343.5	9179.4
21	.60	.20	.79	.39	.98	.58	.18	.77	.37	5.8	1.6	7.5	3.2	9.0
22	.60	.19	.79	.38	.98	.57	.17	.76	.36	5.7	1.5	7.2	2.9	8.6
23	.60	.19	.78	.38	.97	.57	.16	.75	.35	5.7	1.3	7.0	2.6	8.3
24	.60	.19	.78	.37	.97	.56	.15	.74	.34	5.6	1.2	6.7	2.3	7.9
8 25	30.60	61.18	91.77	122.37	152.96	183.55	214.14	244.73	275.32	1835.5	3671.0	5506.5	7342.0	9177.5
26	.59	.18	.77	.36	.95	.54	.14	.72	.31	5.4	0.8	6.3	1.7	7.1
27	.59	.18	.77	.36	.95	.53	.13	.71	.30	5.3	0.7	6.0	1.4	6.7
28	.59	.18	.76	.35	.94	.53	.12	.70	.29	5.3	0.5	5.8	1.0	6.3
29	.59	.17	.76	.35	.94	.52	.11	.69	.28	5.2	0.4	5.5	0.7	5.9
8 30	30.59	61.17	91.76	122.34	152.93	183.51	214.10	244.68	275.27	1835.1	3670.2	5505.3	7340.4	9175.5
31	.59	.17	.75	.34	.92	.50	.09	.67	.26	5.0	70.0	5.1	40.1	5.1
32	.59	.16	.75	.33	.92	.49	.08	.66	.25	4.9	69.9	4.8	39.8	4.7
33	.58	.16	.74	.33	.91	.49	.07	.65	.23	4.9	9.7	4.6	9.4	4.3
34	.58	.16	.74	.32	.90	.48	.06	.64	.22	4.8	9.6	4.3	9.1	3.9
8 35	30.58	61.15	91.74	122.32	152.89	183.47	214.05	244.62	275.21	1834.7	3669.4	5504.1	7338.8	9173.5
36	.58	.15	.73	.31	.89	.46	.04	.61	.20	4.6	9.2	3.9	8.5	3.1
37	.58	.15	.73	.31	.88	.45	.03	.60	.19	4.5	9.1	3.6	8.2	2.7
38	.57	.15	.72	.30	.87	.45	.02	.59	.17	4.5	8.9	3.4	7.8	2.3
39	.57	.14	.72	.30	.87	.44	.01	.58	.16	4.4	8.8	3.1	7.5	1.9
8 40	30.57	61.14	91.72	122.29	152.86	183.43	214.00	244.57	275.15	1834.3	3668.6	5502.9	7337.2	9171.5
41	.57	.14	.71	.28	.85	.42	3.99	.56	.14	4.2	8.4	2.7	6.9	1.1
42	.57	.14	.71	.28	.85	.41	.98	.55	.12	4.1	8.3	2.4	6.6	0.7
43	.57	.13	.70	.27	.84	.41	.97	.54	.11	4.1	8.1	2.2	6.2	70.3
44	.57	.13	.70	.27	.83	.40	.96	.53	.10	4.0	8.0	1.9	5.9	69.9
8 45	30.57	61.13	91.70	122.26	152.82	183.39	213.95	244.51	275.09	1833.9	3667.8	5501.7	7335.6	9169.5
46	.56	.13	.69	.25	.82	.38	.95	.50	.07	3.8	7.6	1.5	5.3	9.1
47	.56	.13	.69	.25	.81	.37	.94	.49	.06	3.7	7.5	1.2	4.9	8.7
48	.56	.12	.68	.24	.80	.36	.93	.48	.05	3.6	7.3	1.0	4.6	8.2
49	.56	.12	.68	.24	.80	.36	.92	.47	.03	3.6	7.2	0.7	4.2	7.8
8 50	30.56	61.12	91.67	122.23	152.79	183.35	213.91	244.46	275.02	1833.5	3667.0	5500.5	7333.9	9167.4
51	.56	.12	.67	.23	.78	.34	.90	.45	.01	3.4	6.8	0.2	3.6	7.0
52	.56	.11	.67	.22	.78	.33	.89	.44	5.00	3.3	6.6	5500.0	3.3	6.6
53	.55	.11	.66	.22	.77	.33	.88	.43	4.98	3.3	6.5	499.7	2.9	6.1
54	.55	.11	.66	.21	.76	.32	.87	.42	.97	3.2	6.3	9.5	2.6	5.7
8 55	30.55	61.10	91.65	122.21	152.75	183.31	213.86	244.40	274.96	1833.1	3666.1	5499.2	7332.3	9165.3
56	.55	.10	.65	.20	.75	.30	.85	.39	.95	3.0	5.9	9.0	2.0	4.9
57	.55	.10	.64	.20	.74	.29	.84	.38	.94	2.9	5.8	8.7	1.6	4.5
58	.54	.10	.64	.19	.73	.28	.83	.37	.92	2.8	5.6	8.5	1.3	4.1
59	.54	.09	.64	.19	.73	.28	.82	.36	.91	2.8	5.5	8.2	0.9	3.7
8 60	30.54	61.09	91.63	122.18	152.72	183.27	213.81	244.35	274.90	1832.7	3665.3	5498.0	7330.6	9163.3

Lat.	Latitude 8° to 9°—Meridional arcs.						Latitude 8°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
8 00	30.719			1843.15					
1	9	1	30.72	.15	1	1 843.2	0 1	1 837.4	
2	9	2	61.44	.15	2	3 686.3	2	3 674.8	0.1
3	9	3	92.16	.16	3	5 529.5	3	5 512.2	0.3
4	9	4	122.88	.16	4	7 372.6	4	7 349.6	0.6
8 05	30.719	5	153.60	1843.16	5	9 215.8	0 5	9 187.0	0.9
6	9	6	184.32	.16	6	11 058.9	6	11 024.4	1.3
7	9	7	215.04	.16	7	12 902.1	7	12 861.9	1.8
8	9	8	245.76	.16	8	14 745.3	8	14 699.3	2.4
9	9	9	276.48	.16	9	16 588.4	9	16 536.7	3.0
8 10	30.719	10	307.20	1843.17	10	18 431.6	0 10	18 374.1	3.7
11	9	1	337.92	.17	1	20 274.8	15	27 561.1	8.4
12	19	2	368.64	.17	2	22 117.9	20	36 748.2	14.9
13	20	3	399.36	.17	3	23 961.1	25	45 935.2	23.2
14	0	4	430.08	.17	4	25 804.3	30	55 122.3	33.5
8 15	30.720	15	460.80	1843.17	15	27 647.4	0 35	64 309.3	45.6
16	0	6	491.52	.17	6	29 490.6	40	73 496.4	59.5
17	0	7	522.24	.18	7	31 333.8	45	82 683.4	75.3
18	0	8	552.96	.18	8	33 177.0	50	91 870.4	93.0
19	0	9	583.68	.18	9	35 020.2	55	101 057.5	112.5
8 20	30.720	20	614.40	1843.18	20	36 863.3	1 00	110 244.5	133.9
21	0	1	645.12	.18	1	38 706.5	05	119 431.5	157.1
22	0	2	675.84	.18	2	40 549.7	10	128 618.5	182.2
23	0	3	706.56	.19	3	42 392.9	15	137 805.5	209.2
24	0	4	737.28	.19	4	44 236.1	20	146 992.5	238.0
8 25	30.720	25	768.00	1843.19	25	46 079.3	1 25	156 179.5	268.7
26	0	6	798.72	.19	6	47 922.5	30	165 366.5	301.3
27	0	7	829.44	.19	7	49 765.6	35	174 553.4	335.7
28	0	8	860.16	.19	8	51 608.8	40	183 740.4	371.9
29	0	9	890.88	.19	9	53 452.0	45	192 927.4	410.0
8 30	30.720	30	921.60	1843.20	30	55 295.2	1 50	202 114.3	450.0
31	0	1	952.32	.20	1	57 138.4	55	211 301.3	491.9
32	0	2	983.04	.20	2	58 981.6	2 00	220 488	536
33	0	3	1 013.76	.20	3	60 824.8	3 00	330 730	1 205
34	0	4	1 044.48	.20	4	62 668.0	4 00	440 971	2 142
8 35	30.720	35	1 075.20	1843.20	35	64 511.2	5 00	551 209	3 347
36	0	6	1 105.92	.20	6	66 354.4	6 00	661 444	4 820
37	0	7	1 136.64	.21	7	68 197.6	7 00	771 675	6 561
38	0	8	1 167.36	.21	8	70 040.8	8 00	881 901	8 569
39	0	9	1 198.08	.21	9	71 884.0	9 00	992 122	10 845
8 40	30.720	40	1 228.80	1843.21	40	73 727.2	10 00	1 102 337	13 389
41	0	1	1 259.52	.21	1	75 570.4	11 00	1 212 546	16 200
42	0	2	1 290.24	.21	2	77 413.6	12 00	1 322 747	19 279
43	0	3	1 320.96	.22	3	79 256.8	13 00	1 432 940	22 626
44	0	4	1 351.68	.22	4	81 100.1	14 00	1 543 126	26 240
8 45	30.720	45	1 382.40	1843.22	45	82 943.3	15 00	1 653 302	30 123
46	0	6	1 413.12	.22	6	84 786.5	16 00	1 763 469	34 274
47	0	7	1 443.84	.22	7	86 629.7	17 00	1 873 626	38 692
48	0	8	1 474.56	.22	8	88 472.9	18 00	1 983 771	43 378
49	0	9	1 505.28	.22	9	90 316.2	19 00	2 093 904	48 330
8 50	30.720	50	1 536.00	1843.23	50	92 159.4	20 00	2 204 024	53 548
51	0	1	1 566.72	.23	1	94 002.6	21 00	2 314 131	59 034
52	0	2	1 597.44	.23	2	95 845.9	22 00	2 424 225	64 789
53	1	3	1 628.16	.23	3	97 689.1	23 00	2 534 305	70 811
54	1	4	1 658.88	.23	4	99 532.3	24 00	2 644 370	77 101
8 55	30.721	55	1 689.60	1843.23	55	101 375.6	25 00	2 754 420	83 658
56	1	6	1 720.32	.24	6	103 218.8	26 00	2 864 454	90 482
57	1	7	1 751.04	.24	7	105 062.0	27 00	2 974 470	97 573
58	1	8	1 781.76	.24	8	106 905.3	28 00	3 084 468	104 932
59	1	9	1 812.48	.24	9	108 748.5	29 00	3 194 449	112 558
8 60	30.721	60	1 843.20	1843.24	60	110 591.8	30 00	3 304 411	120 451

Latitude 9° to 10°—Arcs of the parallel in meters.

Lat. ° ′	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
9 00	30.54	61.09	91.63	122.18	152.72	183.27	213.81	244.35	274.90	1832.7	3665.3	5498.0	7330.6	9163.3
1	.54	.09	.63	.17	.71	.26	.80	.34	.89	2.6	5.1	7.7	30.3	2.9
2	.54	.08	.62	.17	.71	.25	.79	.33	.87	2.5	5.0	7.5	29.9	2.4
3	.54	.08	.62	.16	.70	.24	.78	.32	.86	2.4	4.8	7.2	9.6	2.0
4	.54	.08	.61	.16	.69	.23	.77	.31	.85	2.3	4.7	7.0	9.2	1.5
9 05	30.54	61.07	91.61	122.15	152.68	183.22	213.76	244.29	274.83	1832.2	3664.5	5496.7	7328.9	9161.1
6	.53	.07	.61	.14	.68	.21	.75	.28	.82	2.1	4.3	6.4	8.6	0.7
7	.53	.07	.60	.14	.67	.21	.74	.27	.81	2.1	4.1	6.2	8.2	60.3
8	.53	.07	.60	.13	.66	.20	.73	.26	.80	2.0	4.0	5.9	7.9	59.8
9	.53	.06	.59	.13	.66	.19	.72	.25	.78	1.9	3.8	5.7	7.5	9.4
9 10	30.53	61.06	91.59	122.12	152.65	183.18	213.71	244.24	274.77	1831.8	3663.6	5495.4	7327.2	9159.0
11	.53	.06	.59	.11	.64	.17	.70	.23	.76	1.7	3.4	5.1	6.9	8.6
12	.53	.05	.58	.11	.64	.16	.69	.22	.74	1.6	3.3	4.9	6.5	8.2
13	.53	.05	.58	.10	.63	.15	.68	.21	.73	1.5	3.1	4.6	6.2	7.7
14	.53	.05	.57	.10	.62	.15	.67	.20	.72	1.5	3.0	4.4	5.8	7.3
9 15	30.53	61.04	91.57	122.09	152.61	183.14	213.66	244.18	274.70	1831.4	3662.8	5494.1	7325.5	9156.9
16	.52	.04	.57	.08	.61	.13	.65	.17	.69	1.3	2.6	3.8	5.2	6.5
17	.52	.04	.56	.08	.60	.12	.64	.16	.68	1.2	2.4	3.6	4.8	6.0
18	.52	.04	.56	.07	.59	.11	.63	.15	.67	1.1	2.3	3.3	4.5	5.6
19	.52	.03	.55	.07	.59	.10	.62	.14	.65	1.0	2.1	3.1	4.1	5.1
9 20	30.52	61.03	91.55	122.06	152.58	183.09	213.61	244.13	274.64	1830.9	3661.9	5492.8	7323.8	9154.7
21	.52	.03	.54	.05	.57	.08	.60	.12	.63	0.8	1.7	2.5	3.4	4.3
22	.52	.02	.54	.05	.57	.07	.59	.11	.61	0.7	1.5	2.3	3.1	3.8
23	.51	.02	.53	.04	.56	.07	.58	.09	.60	0.7	1.4	2.0	2.7	3.4
24	.51	.02	.53	.04	.55	.06	.57	.08	.59	0.6	1.2	1.8	2.4	2.9
9 25	30.51	61.01	91.53	122.03	152.54	183.05	213.56	244.07	274.57	1830.5	3661.0	5491.5	7322.0	9152.5
26	.51	.01	.52	.02	.54	.04	.55	.06	.56	0.4	0.8	1.2	1.7	2.1
27	.51	.01	.52	.02	.53	.03	.54	.05	.55	0.3	0.6	1.0	1.3	1.6
28	.50	.01	.51	.01	.52	.03	.53	.03	.54	0.3	0.5	0.7	1.0	1.2
29	.50	.00	.51	.01	.52	.02	.52	.02	.52	0.2	0.3	0.5	0.6	0.7
9 30	30.50	61.00	91.50	122.00	152.51	183.01	213.51	244.01	274.51	1830.1	3660.1	5490.2	7320.3	9150.3
31	.50	1.00	.50	1.99	.50	3.00	.50	4.00	.50	30.0	59.9	89.9	19.9	49.9
32	.50	0.99	.49	.99	.49	2.99	.49	3.99	.48	29.9	9.7	9.7	9.6	9.4
33	.50	.99	.49	.98	.49	.98	.48	.97	.47	9.8	9.6	9.4	9.2	9.0
34	.50	.99	.48	.98	.48	.97	.47	.96	.46	9.7	9.4	9.2	8.9	8.5
9 35	30.50	60.98	91.48	121.97	152.47	182.96	213.46	243.95	274.44	1829.6	3659.2	5488.9	7318.5	9148.1
36	.49	.98	.48	.96	.46	.96	.44	.94	.43	9.6	9.0	8.6	8.1	7.7
37	.49	.98	.47	.96	.45	.95	.43	.93	.42	9.5	8.9	8.3	7.8	7.2
38	.49	.98	.47	.95	.45	.94	.42	.91	.41	9.4	8.7	8.1	7.4	6.8
39	.49	.97	.46	.95	.44	.93	.41	.90	.39	9.3	8.6	7.8	7.1	6.3
9 40	30.49	60.97	91.46	121.94	152.43	182.92	213.40	243.89	274.38	1829.2	3658.4	5487.5	7316.7	9145.9
41	.49	.97	.45	.93	.42	.91	.39	.88	.37	9.1	8.2	7.2	6.3	5.4
42	.49	.96	.45	.93	.42	.90	.38	.87	.35	9.0	8.0	7.0	6.0	5.0
43	.48	.96	.45	.92	.41	.89	.37	.85	.34	8.9	7.8	6.7	5.6	4.5
44	.48	.96	.44	.92	.40	.88	.36	.84	.32	8.8	7.6	6.5	5.3	4.1
9 45	30.48	60.95	91.44	121.91	152.39	182.87	213.35	243.83	274.31	1828.7	3657.4	5486.2	7314.9	9143.6
46	.48	.95	.43	.90	.39	.86	.34	.82	.30	8.6	7.2	5.9	4.5	3.1
47	.48	.95	.43	.90	.38	.85	.33	.81	.28	8.5	7.0	5.6	4.2	2.7
48	.47	.95	.42	.89	.37	.85	.32	.79	.27	8.5	6.9	5.4	3.8	2.2
49	.47	.94	.42	.89	.37	.84	.31	.78	.25	8.4	6.7	5.1	3.5	1.8
9 50	30.47	60.94	91.41	121.88	152.36	182.83	213.30	243.77	274.24	1828.3	3656.5	5484.8	7313.1	9141.3
51	.47	.94	.41	.87	.35	.82	.29	.76	.23	8.2	6.3	4.5	2.7	0.8
52	.47	.93	.40	.87	.34	.81	.28	.75	.21	8.1	6.1	4.2	2.3	40.4
53	.47	.93	.40	.86	.34	.80	.27	.73	.20	8.0	6.0	4.0	2.0	39.9
54	.47	.93	.39	.86	.33	.79	.26	.72	.18	7.9	5.8	3.7	1.6	9.5
9 55	30.47	60.92	91.39	121.85	152.32	182.78	213.25	243.71	274.17	1827.8	3655.6	5483.4	7311.2	9139.0
56	.46	.92	.39	.84	.31	.77	.23	.70	.16	7.7	5.4	3.1	0.8	8.5
57	.46	.92	.38	.84	.30	.76	.22	.69	.14	7.6	5.2	2.8	0.5	8.1
58	.46	.92	.38	.83	.30	.75	.21	.67	.13	7.5	5.1	2.6	10.1	7.6
59	.46	.91	.37	.83	.29	.74	.20	.66	.11	7.4	4.9	2.3	09.8	7.2
9 60	30.46	60.91	91.37	121.82	152.28	182.73	213.19	243.65	274.10	1827.3	3654.7	5482.0	7309.4	9136.7

Lat.		Latitude 9° to 10°—Meridional arcs.						Latitude 9°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
9	00	30.721			1843.24						
	1	1	1	30.72	.25	1	1 843.2	0	1	1 832.6	
	2	1	2	61.44	.25	2	3 686.5		2	3 665.3	0.2
	3	1	3	92.16	.25	3	5 529.7		3	5 498.0	0.4
	4	1	4	122.89	.25	4	7 373.0		4	7 330.6	0.7
9	05	30.721	5	153.61	1843.25	5	9 216.2	0	5	9 163.3	1.0
	6	1	6	184.33	.25	6	11 059.5		6	10 995.9	1.5
	7	1	7	215.05	.26	7	12 902.8		7	12 828.6	2.0
	8	1	8	245.77	.26	8	14 746.0		8	14 661.2	2.7
	9	1	9	276.49	.26	9	16 589.3		9	16 493.9	3.4
9	10	30.721	10	307.22	1843.26	10	18 432.5	0	10	18 326.5	4.2
	11	1	1	337.94	.26	1	20 275.8		15	27 489.8	9.4
	12	1	2	368.66	.26	2	22 119.1		20	36 653.1	16.7
	13	1	3	399.38	.27	3	23 962.3		25	45 816.4	26.1
	14	1	4	430.10	.27	4	25 805.6		30	54 979.6	37.5
9	15	30.721	15	460.82	1843.27	15	27 648.9	0	35	64 142.9	51.1
	16	1	6	491.55	.27	6	29 492.1		40	73 306.2	66.7
	17	1	7	522.27	.27	7	31 335.4		45	82 469.4	84.4
	18	1	8	552.99	.28	8	33 178.7		50	91 632.7	104.2
	19	1	9	583.71	.28	9	35 022.0		55	100 795.9	126.1
9	20	30.721	20	614.43	1843.28	20	36 865.3	1	00	109 959.2	150.1
	21	1	1	645.15	.28	1	38 708.5		05	119 122.4	176.2
	22	1	2	675.88	.28	2	40 551.8		10	128 285.6	204.3
	23	1	3	706.60	.28	3	42 395.1		15	137 448.9	234.6
	24	1	4	737.32	.29	4	44 238.4		20	146 612.1	266.9
9	25	30.721	25	768.04	1843.29	25	46 081.7	1	25	155 775.3	301.3
	26	1	6	798.76	.29	6	47 925.0		30	164 938.5	337.8
	27	2	7	829.48	.29	7	49 768.3		35	174 101.7	376.3
	28	2	8	860.21	.29	8	51 611.5		40	183 264.8	417.0
	29	2	9	890.93	.29	9	53 454.8		45	192 428.0	459.7
9	30	30.722	30	921.65	1843.30	30	55 298.1	1	50	201 591.2	504.5
	31	2	1	952.37	.30	1	57 141.4		55	210 754.3	551.4
	32	2	2	983.09	.30	2	58 984.7	2	00	219 917	600
	33	2	3	1 013.81	.30	3	60 828.0	3	00	329 874	1 351
	34	2	4	1 044.53	.30	4	62 671.3	4	00	439 828	2 402
9	35	30.722	35	1 075.26	1843.31	35	64 514.6	5	00	549 779	3 753
	36	2	6	1 105.98	.31	6	66 357.9	6	00	659 726	5 404
	37	2	7	1 136.70	.31	7	68 201.2	7	00	769 668	7 355
	38	2	8	1 167.42	.31	8	70 044.6	8	00	879 604	9 607
	39	2	9	1 198.14	.31	9	71 887.9	9	00	989 534	12 158
9	40	30.722	40	1 228.86	1843.31	40	73 731.2	10	00	1 099 456	15 010
	41	2	1	1 259.59	.32	1	75 574.5	11	00	1 209 370	18 162
	42	2	2	1 290.31	.32	2	77 417.8	12	00	1 319 275	21 614
	43	2	3	1 321.03	.32	3	79 261.1	13	00	1 429 171	25 367
	44	2	4	1 351.75	.32	4	81 104.5	14	00	1 539 055	29 419
9	45	30.722	45	1 382.47	1843.32	45	82 947.8	15	00	1 648 928	33 770
	46	2	6	1 413.19	.33	6	84 791.1	16	00	1 758 789	38 422
	47	2	7	1 443.92	.33	7	86 634.4	17	00	1 868 637	43 374
	48	2	8	1 474.64	.33	8	88 477.8	18	00	1 978 471	48 626
	49	2	9	1 505.36	.33	9	90 321.1	19	00	2 088 289	54 178
9	50	30.722	50	1 536.08	1843.33	50	92 164.4	20	00	2 198 093	60 029
	51	2	1	1 566.80	.33	1	94 007.7	21	00	2 307 880	66 180
	52	2	2	1 597.52	.34	2	95 851.1	22	00	2 417 650	72 631
	53	2	3	1 628.25	.34	3	97 694.4	23	00	2 527 402	79 382
	54	2	4	1 658.97	.34	4	99 537.8	24	00	2 637 136	86 433
9	55	30.722	55	1 689.69	1843.34	55	101 381.1	25	00	2 746 848	93 783
	56	2	6	1 720.41	.34	6	103 224.4	26	00	2 856 541	101 432
	57	2	7	1 751.13	.35	7	105 067.8	27	00	2 966 213	109 381
	58	2	8	1 781.85	.35	8	106 911.1	28	00	3 075 862	117 629
	59	2	9	1 812.58	.35	9	108 754.4	29	00	3 185 488	126 177
9	60	30.723	60	1 843.30	1843.35	60	110 597.8	30	00	3 295 091	135 024

Latitude 10° to 11°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
10 00	30.46	60.91	91.37	121.82	152.28	182.73	213.19	243.65	274.10	1827.3	3654.7	5482.0	7309.4	9136.7
1	.46	.91	.36	.81	.27	.72	.18	.64	.09	7.2	4.5	1.7	9.0	6.2
2	.46	.90	.36	.81	.26	.71	.17	.62	.07	7.1	4.3	1.4	8.6	5.8
3	.45	.90	.35	.80	.26	.71	.16	.61	.06	7.1	4.1	1.2	8.3	5.3
4	.45	.90	.35	.80	.25	.70	.15	.60	.04	7.0	3.9	0.9	7.9	4.9
10 05	30.45	60.89	91.34	121.79	152.24	182.69	213.13	243.58	274.03	1826.9	3653.7	5480.6	7307.5	9134.4
6	.45	.89	.34	.78	.23	.68	.12	.57	.02	6.8	3.5	0.3	7.1	3.9
7	.45	.89	.33	.78	.22	.67	.11	.56	4.00	6.7	3.3	80.0	6.7	3.4
8	.44	.89	.33	.77	.22	.66	.10	.55	3.99	6.6	3.2	79.8	6.4	3.0
9	.44	.88	.33	.77	.21	.65	.09	.53	.97	6.5	3.0	9.5	6.0	2.5
10 10	30.44	60.88	91.32	121.76	152.20	182.64	213.08	243.52	273.96	1826.4	3652.8	5479.2	7305.6	9132.0
11	.44	.88	.32	.75	.19	.63	.07	.51	.95	6.3	2.6	8.9	5.2	1.5
12	.44	.87	.31	.75	.18	.62	.06	.50	.93	6.2	2.4	8.6	4.8	1.0
13	.43	.87	.31	.74	.18	.61	.05	.48	.92	6.1	2.3	8.4	4.5	0.6
14	.43	.87	.30	.74	.17	.60	.04	.47	.90	6.0	2.1	8.1	4.1	30.1
10 15	30.43	60.86	91.30	121.73	152.16	182.59	213.02	243.46	273.89	1825.9	3651.9	5477.8	7303.7	9129.6
16	.43	.86	.29	.72	.15	.58	.01	.45	.88	5.8	1.7	7.5	3.3	9.1
17	.43	.86	.29	.72	.14	.57	3.00	.44	.86	5.7	1.5	7.2	2.9	8.7
18	.42	.86	.28	.71	.14	.57	2.99	.42	.85	5.7	1.3	7.0	2.6	8.2
19	.42	.85	.28	.71	.13	.56	.98	.41	.83	5.6	1.1	6.7	2.2	7.8
10 20	30.42	60.85	91.27	121.70	152.12	182.55	212.97	243.40	273.82	1825.5	3650.9	5476.4	7301.8	9127.3
21	.42	.85	.27	.69	.11	.54	.96	.39	.81	5.4	0.7	6.1	1.4	6.8
22	.42	.84	.26	.69	.10	.53	.95	.37	.79	5.3	0.5	5.8	1.0	6.3
23	.42	.84	.26	.68	.10	.52	.94	.36	.78	5.2	0.3	5.5	0.7	5.8
24	.42	.84	.25	.67	.09	.51	.93	.34	.76	5.1	50.1	5.2	300.3	5.3
10 25	30.42	60.83	91.25	121.67	152.08	182.50	212.91	243.33	273.75	1825.0	3649.9	5474.9	7299.9	9124.8
26	.41	.83	.24	.66	.07	.49	.90	.32	.73	4.9	9.7	4.6	9.5	4.3
27	.41	.83	.24	.65	.06	.48	.89	.30	.72	4.8	9.5	4.3	9.1	3.8
28	.41	.83	.23	.64	.06	.47	.88	.29	.70	4.7	9.4	4.0	8.7	3.4
29	.41	.82	.23	.64	.05	.46	.87	.27	.69	4.6	9.2	3.7	8.3	2.9
10 30	30.41	60.82	91.22	121.63	152.04	182.45	212.86	243.26	273.67	1824.5	3649.0	5473.4	7297.9	9122.4
31	.41	.82	.22	.62	.03	.44	.85	.25	.66	4.4	8.8	3.1	7.5	1.9
32	.41	.81	.21	.62	.02	.43	.84	.23	.64	4.3	8.6	2.8	7.1	1.4
33	.40	.81	.21	.61	.02	.42	.82	.22	.63	4.2	8.4	2.6	6.7	0.9
34	.40	.80	.20	.61	.01	.41	.81	.21	.61	4.1	8.2	2.3	6.3	20.4
10 35	30.40	60.80	91.20	121.60	152.00	182.40	212.80	243.20	273.60	1824.0	3648.0	5472.0	7295.9	9119.9
36	.40	.80	.19	.59	1.99	.39	.79	.18	.58	3.9	7.8	1.7	5.5	9.4
37	.40	.79	.19	.59	.98	.38	.78	.17	.57	3.8	7.6	1.4	5.1	8.9
38	.39	.79	.18	.58	.98	.37	.76	.16	.55	3.7	7.4	1.1	4.8	8.5
39	.39	.78	.18	.58	.97	.36	.75	.14	.54	3.6	7.2	0.8	4.4	8.0
10 40	30.39	60.78	91.17	121.57	151.96	182.35	212.74	243.13	273.52	1823.5	3647.0	5470.5	7294.0	9117.5
41	.39	.78	.17	.56	.95	.34	.73	.12	.51	3.4	6.8	70.2	3.6	7.0
42	.39	.77	.16	.56	.94	.33	.72	.10	.49	3.3	6.6	69.9	3.2	6.5
43	.38	.77	.16	.55	.93	.32	.70	.09	.48	3.2	6.4	9.6	2.8	6.0
44	.38	.77	.15	.54	.92	.31	.69	.08	.46	3.1	6.2	9.3	2.4	5.5
10 45	30.38	60.76	91.15	121.53	151.91	182.30	212.68	243.06	273.45	1823.0	3646.0	5469.0	7292.0	9115.0
46	.38	.76	.14	.53	.91	.29	.67	.05	.43	2.9	5.8	8.7	1.6	4.5
47	.38	.76	.14	.52	.90	.28	.66	.04	.42	2.8	5.6	8.4	1.2	4.0
48	.37	.76	.13	.51	.89	.27	.64	.03	.40	2.7	5.4	8.1	0.8	3.5
49	.37	.75	.13	.51	.88	.26	.63	.01	.39	2.6	5.2	7.8	0.4	3.0
10 50	30.37	60.75	91.12	121.50	151.87	182.25	212.62	243.00	273.37	1822.5	3645.0	5467.5	7290.0	9112.5
51	.37	.75	.12	.49	.86	.24	.61	2.99	.36	2.4	4.8	7.2	89.6	2.0
52	.37	.74	.11	.49	.85	.23	.60	.97	.34	2.3	4.6	6.9	9.2	1.5
53	.37	.74	.11	.48	.85	.22	.59	.96	.33	2.2	4.4	6.6	8.7	0.9
54	.37	.74	.10	.47	.84	.21	.58	.94	.31	2.1	4.2	6.3	8.3	10.4
10 55	30.37	60.73	91.10	121.47	151.83	182.20	212.56	242.93	273.30	1822.0	3644.0	5466.0	7287.9	9109.9
56	.36	.73	.09	.46	.82	.19	.55	.92	.28	1.9	3.8	5.7	7.5	9.4
57	.36	.73	.09	.45	.81	.18	.54	.90	.27	1.8	3.6	5.4	7.1	8.9
58	.36	.73	.08	.44	.81	.17	.53	.89	.25	1.7	3.4	5.0	6.7	8.4
59	.36	.72	.08	.44	.80	.16	.52	.87	.24	1.6	3.2	4.7	6.3	7.9
10 60	30.36	60.72	91.07	121.43	151.79	182.15	212.51	242.86	273.22	1821.5	3642.0	5464.4	7285.9	9107.4

Lat.	Latitude 10° to 11°—Meridional arcs.						Latitude 10°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
10 00	30.723			1843.35					
1	3	1	30.72	.35	1	1 843.4	0 1	1 827.3	
2	3	2	61.45	.35	2	3 686.7	2	3 654.7	0.2
3	3	3	92.17	.36	3	5 530.1	3	5 482.0	0.4
4	3	4	122.89	.36	4	7 373.4	4	7 309.4	0.7
10 05	30.723	5	153.62	1843.36	5	9 216.8	0 5	9 136.7	1.2
6	3	6	184.34	.36	6	11 060.1	6	10 964.1	1.7
7	3	7	215.06	.36	7	12 903.5	7	12 791.4	2.3
8	3	8	245.79	.37	8	14 746.9	8	14 618.7	3.0
9	3	9	276.51	.37	9	16 590.2	9	16 446.1	3.7
10 10	30.723	10	307.23	1843.37	10	18 433.6	0 10	18 273.4	4.6
1	3	1	337.96	.37	1	20 277.0	15	27 410.2	10.4
2	3	2	368.68	.37	2	22 120.4	20	36 546.9	18.5
3	3	3	399.41	.38	3	23 963.7	25	45 683.6	28.8
4	3	4	430.13	.38	4	25 807.1	30	54 820.3	41.5
10 15	30.723	15	460.85	1843.38	15	27 650.5	0 35	63 957.0	56.5
6	3	6	491.58	.38	6	29 493.9	40	73 093.7	73.8
7	3	7	522.30	.38	7	31 337.3	45	82 230.4	93.5
8	3	8	553.02	.39	8	33 180.7	50	91 367.1	115.4
9	3	9	583.75	.39	9	35 024.0	55	100 503.8	139.6
10 20	30.723	20	614.47	1843.39	20	36 867.4	1 00	109 640.5	166.1
1	3	1	645.19	.39	1	38 710.8	05	118 777.2	195.0
2	3	2	675.92	.39	2	40 554.2	10	127 913.9	226.1
3	3	3	706.64	.40	3	42 397.6	15	137 050.5	259.6
4	3	4	737.36	.40	4	44 241.0	20	146 187.2	295.4
10 25	30.723	25	768.09	1843.40	25	46 084.4	1 25	155 323.8	333.4
6	3	6	798.81	.40	6	47 927.8	30	164 460.5	373.8
7	3	7	829.53	.40	7	49 771.2	35	173 597.1	416.5
8	3	8	860.26	.41	8	51 614.6	40	182 733.7	461.5
9	3	9	890.98	.41	9	53 458.0	45	191 870.3	508.8
10 30	30.723	30	921.70	1843.41	30	55 301.4	1 50	201 006.9	558.4
1	3	1	952.43	.41	1	57 144.8	55	210 143.5	610.3
2	4	2	983.15	.41	2	58 988.2	2 00	219 280	665
3	4	3	1 013.87	.41	3	60 831.6	3 00	328 917	1 495
4	4	4	1 044.60	.42	4	62 675.0	4 00	438 552	2 658
10 35	30.724	35	1 075.32	1843.42	35	64 518.5	5 00	548 182	4 154
6	4	6	1 106.05	.42	6	66 361.9	6 00	657 808	5 981
7	4	7	1 136.77	.42	7	68 205.3	7 00	767 427	8 140
8	4	8	1 167.49	.42	8	70 048.7	8 00	877 040	10 632
9	4	9	1 198.22	.43	9	71 892.2	9 00	986 644	13 457
10 40	30.724	40	1 228.94	1843.43	40	73 735.6	10 00	1 096 239	16 614
1	4	1	1 259.66	.43	1	75 579.0	11 00	1 205 824	20 102
2	4	2	1 290.39	.43	2	77 422.4	12 00	1 315 398	23 922
3	4	3	1 321.11	.43	3	79 265.9	13 00	1 424 960	28 075
4	4	4	1 351.83	.44	4	81 109.3	14 00	1 534 509	32 560
10 45	30.724	45	1 382.56	1843.44	45	82 952.7	15 00	1 644 044	37 375
6	4	6	1 413.28	.44	6	84 796.2	16 00	1 753 564	42 522
7	4	7	1 444.00	.44	7	86 639.6	17 00	1 863 067	48 002
8	4	8	1 474.73	.44	8	88 483.1	18 00	1 972 554	53 815
9	4	9	1 505.45	.45	9	90 326.5	19 00	2 082 022	59 962
10 50	30.724	50	1 536.17	1843.45	50	92 170.0	20 00	2 191 471	66 440
1	4	1	1 566.90	.45	1	94 013.4	21 00	2 300 900	73 246
2	4	2	1 597.62	.45	2	95 856.9	22 00	2 410 308	80 385
3	4	3	1 628.34	.45	3	97 700.3	23 00	2 519 694	87 855
4	4	4	1 659.07	.46	4	99 543.8	24 00	2 629 057	95 658
10 55	30.724	55	1 689.79	1843.46	55	101 387.2	25 00	2 738 395	103 792
6	4	6	1 720.51	.46	6	103 230.7	26 00	2 847 709	112 256
7	4	7	1 751.24	.46	7	105 074.1	27 00	2 956 996	121 053
8	4	8	1 781.96	.46	8	106 917.6	28 00	3 066 256	130 180
9	4	9	1 812.69	.47	9	108 761.1	29 00	3 175 488	139 639
10 60	30.724	60	1 843.41	1843.47	60	110 604.5	30 00	3 284 690	149 428

Latitude 11° to 12°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
11 00	30.36	60.72	91.07	121.43	151.79	182.15	212.51	242.86	273.22	1821.5	3643.0	5464.4	7285.9	9107.4
1	.36	.72	.07	.42	.78	.14	.50	.85	.21	1.4	2.8	4.1	5.5	6.9
2	.36	.71	.06	.42	.77	.13	.49	.83	.19	1.3	2.6	3.8	5.1	6.4
3	.35	.71	.06	.41	.76	.12	.47	.82	.18	1.2	2.3	3.5	4.7	5.8
4	.35	.70	.05	.40	575	.11	.46	.81	.16	1.1	2.1	3.2	4.3	5.3
11 05	30.35	60.70	91.05	121.39	151.74	182.10	212.45	242.79	273.15	1821.0	3641.9	5462.9	7283.9	9104.8
6	.35	.70	.04	.39	.74	.09	.44	.78	.13	0.9	1.7	2.6	3.5	4.3
7	.35	.69	.04	.38	.73	.08	.43	.77	.12	0.8	1.5	2.3	3.1	3.8
8	.34	.69	.03	.37	.72	.07	.41	.76	.10	0.7	1.3	2.0	2.6	3.3
9	.34	.68	.03	.37	.71	.06	.40	.74	.09	0.6	1.1	1.7	2.2	2.8
11 10	30.34	60.68	91.02	121.36	151.70	182.05	212.39	242.73	273.07	1820.5	3640.9	5461.4	7281.8	9102.3
11	.34	.68	.02	.35	.69	.04	.38	.72	.05	0.4	0.7	1.1	1.4	1.8
12	.34	.67	.01	.35	.68	.03	.36	.70	.04	0.3	0.5	0.8	1.0	1.2
13	.33	.67	.01	.34	.68	.01	.35	.69	.02	0.1	0.3	0.4	0.5	0.7
14	.33	.67	.00	.33	.67	2.00	.34	.67	3.01	20.0	40.1	60.1	80.1	100.1
11 15	30.33	60.66	91.00	121.32	151.66	181.99	212.32	242.66	272.99	1819.9	3639.9	5459.8	7279.7	9099.6
16	.33	.66	0.99	.32	.65	.98	.31	.65	.97	9.8	9.7	9.5	9.3	9.1
17	.33	.66	.99	.31	.64	.97	.30	.63	.96	9.7	9.5	9.2	8.9	8.6
18	.32	.66	.98	.30	.64	.96	.29	.62	.94	9.6	9.2	8.8	8.4	8.0
19	.32	.65	.98	.30	.63	.95	.27	.60	.93	9.5	9.0	8.5	8.0	7.5
11 20	30.32	60.65	90.97	121.29	151.62	181.94	212.26	242.59	272.91	1819.4	3638.8	5458.2	7277.6	9097.0
21	.32	.65	.97	.28	.61	.93	.25	.58	.89	9.3	8.6	7.9	7.2	6.5
22	.32	.64	.96	.28	.60	.92	.24	.56	.88	9.2	8.4	7.6	6.8	6.0
23	.32	.64	.95	.27	.59	.91	.22	.55	.86	9.1	8.1	7.2	6.3	5.4
24	.32	.63	.95	.26	.58	.90	.21	.53	.85	9.0	7.9	6.9	5.9	4.9
11 25	30.32	60.63	90.94	121.25	151.57	181.89	212.20	242.52	272.83	1818.9	3637.7	5456.6	7275.5	9094.4
26	.31	.63	.94	.25	.57	.88	.19	.51	.81	8.8	7.5	6.3	5.1	3.9
27	.31	.62	.93	.24	.56	.87	.18	.49	.80	8.7	7.3	6.0	4.7	3.3
28	.31	.62	.93	.23	.55	.85	.16	.48	.78	8.5	7.1	5.6	4.2	2.8
29	.31	.61	.92	.23	.54	.84	.15	.46	.77	8.4	6.9	5.3	3.8	2.2
11 30	30.31	60.61	90.92	121.22	151.53	181.83	212.14	242.45	272.75	1818.3	3636.7	5455.0	7273.4	9091.7
31	.31	.61	.91	.21	.52	.82	.13	.44	.73	8.2	6.5	4.7	3.0	1.2
32	.31	.60	.91	.21	.51	.81	.11	.42	.72	8.1	6.3	4.4	2.5	0.6
33	.30	.60	.90	.20	.50	.80	.10	.41	.70	8.0	6.0	4.0	2.1	90.1
34	.30	.60	.90	.19	.49	.79	.09	.39	.69	7.9	5.8	3.7	1.6	89.5
11 35	30.30	60.59	90.89	121.18	151.48	181.78	212.07	242.38	272.67	1817.8	3635.6	5453.4	7271.2	9089.0
36	.30	.59	.88	.18	.48	.77	.06	.36	.65	7.7	5.4	3.1	0.8	8.5
37	.30	.59	.88	.17	.47	.76	.05	.35	.64	7.6	5.2	2.8	70.4	7.9
38	.29	.59	.87	.16	.46	.75	.04	.33	.62	7.5	4.9	2.4	69.9	7.4
39	.29	.58	.87	.16	.45	.74	.02	.32	.61	7.4	4.7	2.1	9.5	6.8
11 40	30.29	60.58	90.86	121.15	151.44	181.73	212.01	242.30	272.59	1817.3	3634.5	5451.8	7269.1	9086.3
41	.29	.58	.86	.14	.43	.72	2.00	.29	.57	7.2	4.3	1.5	8.7	5.8
42	.29	.57	.85	.14	.42	.71	1.99	.27	.56	7.1	4.1	1.2	8.2	5.2
43	.28	.57	.85	.13	.41	.69	.97	.26	.54	6.9	3.8	0.8	7.8	4.7
44	.28	.56	.84	.12	.40	.68	.96	.24	.53	6.8	3.6	0.5	7.3	4.1
11 45	30.28	60.56	90.84	121.11	151.39	181.67	211.95	242.23	272.51	1816.7	3633.4	5450.2	7266.9	9083.6
46	.28	.56	.83	.11	.39	.66	.94	.22	.49	6.6	3.2	49.9	6.5	3.1
47	.28	.55	.83	.10	.38	.65	.93	.20	.48	6.5	3.0	9.5	6.0	2.5
48	.27	.55	.82	.09	.37	.64	.91	.19	.46	6.4	2.8	9.2	5.6	2.0
49	.27	.54	.81	.09	.36	.63	.90	.17	.45	6.3	2.6	8.8	5.1	1.4
11 50	30.27	60.54	90.81	121.08	151.35	181.62	211.89	242.16	272.43	1816.2	3632.4	5448.5	7264.7	9080.9
51	.27	.54	.80	.07	.34	.61	.88	.15	.41	6.1	2.2	8.2	4.3	80.3
52	.27	.53	.80	.06	.33	.60	.86	.13	.40	6.0	1.9	7.9	3.8	79.8
53	.26	.53	.79	.06	.32	.58	.85	.12	.38	5.8	1.7	7.5	3.4	9.2
54	.26	.52	.79	.05	.31	.57	.84	.10	.36	5.7	1.4	7.2	2.9	8.7
11 55	30.26	60.52	90.78	121.04	151.30	181.56	211.82	242.09	272.34	1815.6	3631.2	5446.9	7262.5	9078.1
56	.26	.52	.77	.03	.30	.55	.81	.07	.33	5.5	1.0	6.6	2.1	7.5
57	.26	.51	.77	.02	.29	.54	.80	.06	.31	5.4	0.8	6.2	1.6	7.0
58	.25	.51	.76	.02	.28	.53	.79	.04	.29	5.3	0.5	5.9	1.2	6.4
59	.25	.50	.76	.01	.27	.52	.77	.03	.28	5.2	0.3	5.5	0.7	5.9
11 60	30.25	60.50	90.75	121.00	151.26	181.51	211.76	242.01	272.26	1815.1	3630.1	5445.2	7260.3	9075.3

Lat.	Latitude 11° to 12°—Meridional arcs.						Latitude 11°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
11 00	30.724			1843.47					-
1	4	1	30.73	.47	1	1 843.5	0 1	1 821.5	0.1
2	5	2	61.45	.47	2	3 686.9	2	3 643.0	0.2
3	5	3	92.18	.47	3	5 530.4	3	5 464.4	0.5
4	5	4	122.90	.48	4	7 373.9	4	7 285.9	0.8
11 05	30.725	5	153.63	1843.48	5	9 217.4	0 5	9 107.4	1.3
6	5	6	184.35	.48	6	11 060.8	6	10 928.9	1.8
7	5	7	215.08	.48	7	12 904.3	7	12 750.4	2.5
8	5	8	245.80	.49	8	14 747.8	8	14 571.8	3.2
9	5	9	276.53	.49	9	16 591.3	9	16 393.3	4.1
11 10	30.725	10	307.26	1843.49	10	18 434.8	0 10	18 214.8	5.1
11	5	1	337.98	.49	1	20 278.3	15	27 322.2	11.4
12	5	2	368.71	.49	2	22 121.8	20	36 429.6	20.2
13	5	3	399.43	.50	3	23 965.3	25	45 537.0	31.6
14	5	4	430.16	.50	4	25 808.8	30	54 644.4	45.5
11 15	30.725	15	460.88	1843.50	15	27 652.3	0 35	63 751.8	61.9
16	5	6	491.61	.50	6	29 495.8	40	72 859.2	80.9
17	5	7	522.33	.50	7	31 339.3	45	81 966.5	102.4
18	5	8	553.06	.51	8	33 182.8	50	91 073.9	126.4
19	5	9	583.78	.51	9	35 026.3	55	100 181.3	152.9
11 20	30.725	20	614.51	1843.51	20	36 869.8	1 00	109 288.7	182.0
21	5	1	645.24	.51	1	38 713.3	05	118 396.0	213.6
22	5	2	675.96	.51	2	40 556.8	10	127 503.4	247.7
23	5	3	706.69	.52	3	42 400.3	15	136 610.7	284.3
24	5	4	737.41	.52	4	44 243.8	20	145 718.0	323.5
11 25	30.725	25	768.14	1843.52	25	46 087.3	1 25	154 825.3	365.2
26	5	6	798.86	.52	6	47 930.9	30	163 932.7	409.4
27	5	7	829.59	.52	7	49 774.4	35	173 039.9	456.2
28	5	8	860.31	.53	8	51 617.9	40	182 147.2	505.5
29	5	9	891.04	.53	9	53 461.4	45	191 254.5	557.3
11 30	30.726	30	921.77	1843.5[illegible]	30	55 305.0	1 50	200 361.7	611.6
31	6	1	952.49	.53	1	57 148.5	55	209 469.0	668.5
32	6	2	983.22	.54	2	58 992.0	2 00	218 576	728
33	6	3	1 013.94	.54	3	60 835.6	3 00	327 861	1 638
34	6	4	1 044.67	.54	4	62 679.1	4 00	437 143	2 911
11 35	30.726	35	1 075.39	1843.54	35	64 522.7	5 00	546 419	4 549
36	6	6	1 106.12	.54	6	66 366.2	6 00	655 690	6 551
37	6	7	1 136.84	.55	7	68 209.8	7 00	764 953	8 916
38	6	8	1 167.57	.55	8	70 053.3	8 00	874 208	11 646
39	6	9	1 198.30	.55	9	71 896.9	9 00	983 453	14 739
11 40	30.726	40	1 229.02	1843.55	40	73 740.4	10 00	1 092 687	18 196
41	6	1	1 259.75	.55	1	75 584.0	11 00	1 201 909	22 016
42	6	2	1 290.47	.56	2	77 427.5	12 00	1 311 117	26 201
43	6	3	1 321.20	.56	3	79 271.1	13 00	1 420 311	30 749
44	6	4	1 351.92	.56	4	81 114.6	14 00	1 529 490	35 663
11 45	30.726	45	1 382.65	1843.56	45	82 958.2	15 00	1 638 652	40 937
46	6	6	1 413.37	.57	6	84 801.8	16 00	1 747 795	46 577
47	6	7	1 444.10	.57	7	86 645.3	17 00	1 856 919	52 579
48	6	8	1 474.82	.57	8	88 488.9	18 00	1 966 022	58 944
49	6	9	1 505.55	.57	9	90 332.5	19 00	2 075 104	65 674
11 50	30.726	50	1 536.28	1843.57	50	92 176.1	20 00	2 184 162	72 764
51	6	1	1 567.00	.58	1	94 019.6	21 00	2 293 196	80 221
52	6	2	1 597.73	.58	2	95 863.2	22 00	2 402 205	88 039
53	6	3	1 628.45	.58	3	97 706.8	23 00	2 511 187	96 221
54	6	4	1 659.18	.58	4	99 550.4	24 00	2 620 142	104 765
11 55	30.726	55	1 689.90	1843.58	55	101 394.0	25 00	2 729 067	113 671
56	6	6	1 720.63	.59	6	103 237.6	26 00	2 837 962	122 940
57	6	7	1 751.35	.59	7	105 081.1	27 00	2 946 825	132 573
58	7	8	1 782.08	.59	8	106 924.7	28 00	3 055 656	142 569
59	7	9	1 812.81	.59	9	108 768.3	29 00	3 164 453	152 926
11 60	30.727	60	1 843.53	1843.60	60	110 611.9	30 00	3 273 215	163 645

Latitude 12° to 13°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
12 00	30.25	60.50	90.75	121.00	151.26	181.51	211.76	242.01	272.26	1815.1	3630.1	5445.2	7260.3	9075.3
1	.25	.50	.75	120.99	.25	.50	.75	2.00	.24	5.0	29.9	4.9	59.8	4.7
2	.25	.49	.74	.99	.24	.49	.73	1.98	.23	4.9	9.7	4.5	9.4	4.2
3	.24	.49	.74	.98	.23	.47	.72	.97	.21	4.7	9.4	4.2	8.9	3.6
4	.24	.48	.73	.97	.22	.46	.71	.95	.19	4.6	9.2	3.8	8.5	3.1
12 05	30.24	60.48	90.73	120.96	151.21	181.45	211.69	241.93	272.17	1814.5	3629.0	5443.5	7258.0	9072.5
6	.24	.48	.72	.96	.20	.44	.68	.92	.16	4.4	8.8	3.2	7.6	1.9
7	.24	.47	.71	.95	.19	.43	.67	.90	.14	4.3	8.6	2.8	7.1	1.4
8	.23	.47	.71	.94	.18	.41	.66	.89	.12	4.1	8.3	2.5	6.7	0.8
9	.23	.46	.70	.94	.17	.40	.64	.87	.11	4.0	8.1	2.1	6.2	70.3
12 10	30.23	60.46	90.70	120.93	151.16	181.39	211.63	241.86	272.09	1813.9	3627.9	5441.8	7255.8	9069.7
11	.23	.46	.69	.92	.15	.38	.62	.85	.07	3.8	7.7	1.5	5.3	9.1
12	.23	.45	.69	.91	.14	.37	.60	.83	.06	3.7	7.4	1.1	4.9	8.6
13	.22	.45	.68	.91	.13	.36	.59	.82	.04	3.6	7.2	0.7	4.4	8.0
14	.22	.45	.68	.90	.12	.35	.57	.80	.02	3.5	6.9	0.3	4.0	7.5
12 15	30.22	60.44	90.67	120.89	151.12	181.34	211.56	241.78	272.00	1813.4	3626.7	5440.1	7253.5	9066.9
16	.22	.44	.66	.88	.11	.33	.55	.77	1.99	3.3	6.5	39.8	3.0	6.3
17	.22	.44	.66	.87	.10	.32	.53	.75	.97	3.2	6.3	9.4	2.6	5.7
18	.21	.44	.65	.87	.09	.30	.52	.74	.95	3.0	6.0	9.1	2.1	5.2
19	.21	.43	.65	.86	.08	.29	.50	.72	.94	2.9	5.8	8.7	1.7	4.6
12 20	30.21	60.43	90.64	120.85	151.07	181.28	211.49	241.71	271.92	1812.8	3625.6	5438.4	7251.2	9064.0
21	.21	.43	.63	.84	.06	.27	.48	.69	.90	2.7	5.4	8.1	0.7	3.4
22	.21	.42	.63	.84	.05	.26	.46	.68	.89	2.6	5.2	7.4	50.3	2.8
23	.20	.42	.62	.83	.04	.24	.45	.66	.87	2.4	4.9	7.7	49.8	2.3
24	.20	.41	.62	.82	.03	.23	.44	.65	.85	2.3	4.7	7.0	9.4	1.7
12 25	30.20	60.41	90.61	120.81	151.02	181.22	211.42	241.63	271.83	1812.2	3624.5	5436.7	7248.9	9061.1
26	.20	.41	.60	.81	.01	.21	.41	.61	.82	2.1	4.3	6.4	8.4	0.5
27	.20	.40	.60	.80	1.00	.20	.40	.60	.80	2.0	4.0	6.0	8.0	60.0
28	.19	.40	.59	.79	0.99	.19	.39	.58	.78	1.9	3.8	5.7	7.5	59.4
29	.19	.39	.59	.79	.98	.18	.37	.57	.77	1.8	3.5	5.3	7.1	8.9
12 30	30.19	60.39	90.58	120.78	150.97	181.17	211.36	241.[illegible]	271.75	1811.7	3623.3	5435.0	7246.6	9058.3
31	.19	.39	.58	.77	.96	.16	.35	.54	.73	1.6	3.1	4.6	6.1	7.7
32	.19	.38	.57	.76	.95	.15	.33	.52	.71	1.5	2.8	4.3	5.7	7.1
33	.18	.38	.56	.76	.94	.13	.32	.51	.70	1.3	2.6	3.9	5.2	6.5
34	.18	.37	.56	.75	.93	.12	.30	.49	.68	1.2	2.3	3.6	4.8	5.9
12 35	30.18	60.37	90.55	120.74	150.92	181.11	211.29	241.47	271.66	1811.1	3622.1	5433.2	7244.3	9055.3
36	.18	.37	.55	.73	.91	.10	.28	.46	.64	1.0	1.9	2.9	3.8	4.7
37	.18	.36	.54	.72	.90	.09	.26	.44	.62	0.9	1.7	2.5	3.3	4.1
38	.17	.36	.54	.72	.89	.07	.25	.43	.61	0.7	1.4	2.2	2.9	3.6
39	.17	.35	.53	.71	.88	.06	.23	.41	.59	0.6	1.2	1.8	2.4	3.0
12 40	30.17	60.35	90.52	120.70	150.87	181.05	211.22	241.40	271.57	1810.5	3621.0	5431.5	7241.9	9052.4
41	.17	.35	.52	.69	.86	.04	.21	.38	.55	0.4	0.8	1.1	1.4	1.8
42	.17	.34	.51	.68	.85	.03	.19	.37	.54	0.3	0.5	0.8	1.0	1.2
43	.17	.34	.51	.68	.84	.01	.18	.35	.52	0.1	0.3	0.4	0.5	0.7
44	.17	.33	.50	.67	.83	1.00	.17	.34	.50	10.0	20.0	30.1	40.1	50.1
12 45	30.17	60.33	90.50	120.66	150.83	180.99	211.15	241.32	271.48	1809.9	3619.8	5429.7	7239.6	9049.5
46	.16	.33	.49	.65	.82	.98	.14	.30	.47	9.8	9.6	9.3	9.1	8.9
47	.16	.32	.48	.64	.81	.97	.13	.29	.45	9.7	9.3	9.0	8.6	8.3
48	.16	.32	.48	.64	.80	.95	.12	.27	.43	9.5	9.1	8.6	8.2	7.7
49	.16	.31	.47	.63	.79	.94	.10	.26	.42	9.4	8.8	8.3	7.7	7.1
12 50	30.16	60.31	90.47	120.62	150.78	180.93	211.09	241.24	271.40	1809.3	3618.6	5427.9	7237.2	9046.5
51	.16	.31	.46	.61	.77	.92	.08	.22	.38	9.2	8.4	7.5	6.7	5.9
52	.16	.30	.45	.60	.76	.91	.06	.21	.36	9.1	8.1	7.2	6.2	5.3
53	.15	.30	.45	.60	.75	.89	.05	.19	.35	8.9	7.9	6.8	5.8	4.7
54	.15	.29	.44	.59	.74	.88	.03	.18	.33	8.8	7.6	6.5	5.3	4.1
12 55	30.15	60.29	90.44	120.58	150.73	180.87	211.02	241.16	271.31	1808.7	3617.4	5426.1	7234.8	9043.5
56	.15	.29	.43	.57	.72	.86	1.01	.14	.29	8.6	7.2	5.7	4.3	2.9
57	.15	.28	.42	.56	.71	.85	0.99	.13	.27	8.5	6.9	5.4	3.8	2.3
58	.14	.28	.42	.56	.70	.83	.98	.11	.26	8.3	6.7	5.0	3.4	1.7
59	.14	.27	.41	.55	.69	.82	.96	.10	.24	8.2	6.4	4.7	2.9	1.1
12 60	30.14	60.27	90.41	120.54	150.68	180.81	210.95	241.08	271.22	1808.1	3616.2	5424.3	7232.4	9040.5

Lat.	Latitude 12° to 13°—Meridional arcs.						Latitude 12°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
12 00	30.727			1843.60					
1	7	1	30.73	.60	1	1 843.6	0 1	1 815.1	0.1
2	7	2	61.46	.60	2	3 687.2	2	3 630.1	0.2
3	7	3	92.18	.60	3	5 530.8	3	5 445.2	0.5
4	7	4	122.91	.60	4	7 374.4	4	7 260.3	0.9
12 05	30.727	5	153.64	1843.61	5	9 218.0	0 5	9 075.3	1.4
6	7	6	184.37	.61	6	11 061.6	6	10 890.4	2.0
7	7	7	215.09	.61	7	12 905.2	7	12 705.5	2.7
8	7	8	245.82	.61	8	14 748.8	8	14 520.5	3.5
9	7	9	276.55	.62	9	16 592.5	9	16 335.6	4.5
12 10	30.727	10	307.28	1843.62	10	18 436.1	0 10	18 150.7	5.5
11	7	1	338.01	.62	1	20 279.7	15	27 226.0	12.4
12	7	2	368.73	.62	2	22 123.3	20	36 301.3	22.0
13	7	3	399.46	.62	3	23 966.9	25	45 376.7	34.3
14	7	4	430.19	.63	4	25 810.6	30	54 452.0	49.4
12 15	30.727	15	460.92	1843.63	15	27 654.2	0 35	63 527.3	67.2
16	7	6	491.64	.63	6	29 497.8	40	72 602.6	87.8
17	7	7	522.37	.63	7	31 341.5	45	81 677.9	111.1
18	7	8	553.10	.64	8	33 185.1	50	90 753.2	137.2
19	7	9	583.83	.64	9	35 028.7	55	99 828.5	166.0
12 20	30.727	20	614.55	1843.64	20	36 872.4	1 00	108 903.8	197.6
21	7	1	645.28	.64	1	38 716.0	05	117 979.0	231.9
22	7	2	676.01	.65	2	40 559.7	10	127 054.3	268.9
23	7	3	706.74	.65	3	42 403.3	15	136 129.6	308.7
24	7	4	737.47	.65	4	44 247.0	20	145 204.8	351.3
12 25	30.728	25	768.19	1843.65	25	46 090.6	1 25	154 280.0	396.6
26	8	6	798.92	.65	6	47 934.3	30	163 355.2	444.6
27	8	7	829.65	.66	7	49 777.9	35	172 430.4	495.4
28	8	8	860.38	.66	8	51 621.6	40	181 505.6	548.9
29	8	9	891.10	.66	9	53 465.3	45	190 580.7	605.1
12 30	30.728	30	921.83	1843.66	30	55 308.9	1 50	199 655.9	664.1
31	8	1	952.56	.67	1	57 152.6	55	208 731.0	725.9
32	8	2	983.29	.67	2	58 996.3	2 00	217 806	790
33	8	3	1 014.02	.67	3	60 839.9	3 00	326 706	1 778
34	8	4	1 044.74	.67	4	62 683.6	4 00	435 601	3 161
12 35	30.728	35	1 075.47	1843.67	35	64 527.2	5 00	544 490	4 940
36	8	6	1 106.20	.68	6	66 370.9	6 00	653 372	7 113
37	8	7	1 136.93	.68	7	68 214.6	7 00	762 246	9 682
38	8	8	1 167.65	.68	8	70 058.3	8 00	871 110	12 646
39	8	9	1 198.38	.68	9	71 902.0	9 00	979 962	16 004
12 40	30.728	40	1 229.11	1843.69	40	73 745.6	10 00	1 088 801	19 757
41	8	1	1 259.84	.69	1	75 589.3	11 00	1 197 626	23 905
42	8	2	1 290.56	.69	2	77 433.0	12 00	1 306 435	28 449
43	8	3	1 321.29	.69	3	79 276.7	13 00	1 415 227	33 387
44	8	4	1 352.02	.70	4	81 120.4	14 00	1 524 000	38 719
12 45	30.728	45	1 382.75	1843.70	45	82 964.1	15 00	1 632 753	44 447
46	8	6	1 413.48	.70	6	84 807.8	16 00	1 741 485	50 569
47	8	7	1 444.20	.70	7	86 651.5	17 00	1 850 194	57 085
48	8	8	1 474.93	.70	8	88 495.2	18 00	1 958 879	63 997
49	8	9	1 505.66	.71	9	90 338.9	19 00	2 067 537	71 303
12 50	30.728	50	1 536.39	1843.71	50	92 182.6	20 00	2 176 168	79 003
51	9	1	1 567.11	.71	1	94 026.3	21 00	2 284 771	87 096
52	9	2	1 597.84	.71	2	95 870.1	22 00	2 393 344	95 584
53	9	3	1 628.57	.72	3	97 713.8	23 00	2 501 885	104 466
54	9	4	1 659.30	.72	4	99 557.5	24 00	2 610 394	113 741
12 55	30.729	55	1 690.03	1843.72	55	101 401.2	25 00	2 718 867	123 410
56	9	6	1 720.75	.72	6	103 244.9	26 00	2 827 305	133 473
57	9	7	1 751.48	.73	7	105 088.7	27 00	2 935 706	143 930
58	9	8	1 782.21	.73	8	106 932.4	28 00	3 044 068	154 780
59	9	9	1 812.94	.73	9	108 776.1	29 00	3 152 390	166 023
12 60	30.729	60	1 843.66	1843.73	60	110 619.8	30 00	3 260 671	177 658

Latitude 13° to 14°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
13 00	30.14	60.27	90.41	120.54	150.68	180.81	210.95	241.08	271.22	1808.1	3616.2	5424.3	7232.4	9040.5
1	.14	.27	.40	.53	.67	.80	.94	.06	.20	8.0	6.0	3.9	1.9	39.9
2	.13	.26	.39	.52	.66	.79	.92	.05	.18	7.9	5.7	3.6	1.4	9.3
3	.13	.26	.39	.52	.65	.77	.91	.03	.16	7.7	5.5	3.2	1.0	8.7
4	.13	.25	.38	.51	.64	.76	.89	.02	.14	7.6	5.2	2.9	0.5	8.1
13 05	30.12	60.25	90.37	120.50	150.62	180.75	210.88	241.00	271.12	1807.5	3615.0	5422.5	7230.0	9037.5
6	.12	.25	.37	.49	.61	.74	.86	0.98	.11	7.4	4.8	2.1	29.5	6.9
7	.12	.24	.36	.48	.60	.73	.85	.97	.09	7.3	4.5	1.8	9.0	6.3
8	.12	.24	.36	.48	.59	.71	.83	.95	.07	7.1	4.3	1.4	8.6	5.6
9	.11	.23	.35	.47	.58	.70	.82	.94	.05	7.0	4.0	1.1	8.1	5.0
13 10	30.11	60.23	90.34	120.46	150.57	180.69	210.80	240.92	271.03	1806.9	3613.8	5420.7	7227.6	9034.4
11	.11	.23	.34	.45	.56	.68	.79	.90	1.01	6.8	3.5	20.3	7.1	3.8
12	.11	.22	.33	.44	.55	.67	.77	.89	0.99	6.7	3.3	19.9	6.6	3.2
13	.10	.22	.33	.44	.54	.65	.76	.87	.98	6.5	3.0	9.6	6.1	2.6
14	.10	.21	.32	.43	.53	.64	.74	.85	.96	6.4	2.8	9.2	5.6	2.0
13 15	30.10	60.21	90.31	120.42	150.52	180.63	210.73	240.84	270.94	1806.3	3612.5	5418.8	7225.1	9031.4
16	.10	.21	.31	.41	.51	.62	.72	.82	.92	6.2	2.3	8.4	4.6	0.8
17	.10	.20	.30	.40	.50	.61	.70	.80	.90	6.1	2.0	8.1	4.1	30.2
18	.09	.20	.29	.39	.49	.59	.69	.78	.89	5.9	1.8	7.7	3.6	29.5
19	.09	.19	.29	.38	.48	.58	.67	.77	.87	5.8	1.5	7.4	3.1	8.9
13 20	30.09	60.19	90.28	120.38	150.47	180.57	210.66	240.75	270.85	1805.7	3611.3	5417.0	7222.6	9028.3
21	.09	.19	.28	.37	.46	.56	.65	.73	.83	5.6	1.1	6.6	2.1	7.7
22	.09	.18	.27	.36	.45	.54	.63	.72	.81	5.4	0.8	6.2	1.6	7.1
23	.08	.18	.26	.35	.44	.53	.62	.70	.79	5.3	0.6	5.9	1.1	6.4
24	.08	.17	.26	.34	.43	.51	.60	.69	.77	5.1	0.3	5.5	0.6	5.8
13 25	30.08	60.17	90.25	120.33	150.42	180.50	210.59	240.67	270.76	1805.0	3610.1	5415.1	7220.1	9025.2
26	.08	.17	.25	.33	.41	.49	.58	.65	.74	4.9	09.8	4.7	19.6	4.6
27	.08	.16	.24	.32	.40	.48	.56	.64	.72	4.8	9.6	4.3	9.1	4.0
28	.07	.16	.23	.31	.39	.46	.55	.62	.70	4.6	9.3	4.0	8.7	3.3
29	.07	.15	.23	.30	.38	.45	.53	.61	.68	4.5	9.1	3.6	8.2	2.7
13 30	30.07	60.15	90.22	120.29	150.37	180.44	210.52	240.59	270.66	1804.4	3608.8	5413.2	7217.7	9022.1
31	.07	.15	.21	.28	.36	.43	.51	.57	.64	4.3	8.6	2.8	7.2	1.5
32	.07	.14	.21	.27	.35	.42	.49	.56	.62	4.2	8.3	2.5	6.7	0.8
33	.06	.14	.20	.27	.34	.40	.48	.54	.60	4.0	8.1	2.1	6.1	20.2
34	.06	.13	.20	.26	.33	.39	.46	.52	.58	3.9	7.8	1.8	5.6	19.5
13 35	30.06	60.13	90.19	120.25	150.31	180.38	210.45	240.51	270.57	1803.8	3607.6	5411.4	7215.1	9018.9
36	.06	.13	.19	.24	.30	.37	.43	.49	.55	3.7	7.3	1.0	4.6	8.6
37	.06	.12	.18	.23	.29	.36	.42	.47	.53	3.6	7.1	0.6	4.1	7.7
38	.05	.12	.17	.23	.28	.34	.40	.45	.51	3.4	6.8	10.3	3.6	7.0
39	.05	.11	.16	.22	.27	.33	.39	.44	.49	3.3	6.6	09.9	3.1	6.4
13 40	30.05	60.11	90.16	120.21	150.26	180.32	210.37	240.42	270.47	1803.2	3606.3	5409.5	7212.6	9015.8
41	.05	.11	.15	.20	.25	.31	.36	.40	.45	3.1	6.0	9.1	2.1	5.2
42	.05	.10	.15	.19	.24	.29	.34	.39	.43	2.9	5.8	8.7	1.6	4.5
43	.04	.10	.14	.18	.23	.28	.33	.37	.41	2.8	5.5	8.4	1.1	3.9
44	.04	.09	.13	.17	.22	.26	.31	.35	.39	2.6	5.3	8.0	0.6	3.2
13 45	30.04	60.09	90.13	120.16	150.21	180.25	210.30	240.33	270.38	1802.5	3605.0	5407.6	7210.1	9012.6
46	.04	.08	.12	.16	.20	.24	.28	.32	.36	2.4	4.8	7.2	09.6	2.0
47	.04	.08	.11	.15	.19	.23	.27	.30	.34	2.3	4.5	6.8	9.1	1.3
48	.03	.07	.11	.14	.18	.21	.25	.28	.32	2.1	4.3	6.4	8.6	0.7
49	.03	.07	.10	.13	.17	.20	.24	.27	.30	2.0	4.0	6.0	8.1	10.0
13 50	30.03	60.06	90.09	120.12	150.16	180.19	210.22	240.25	270.28	1801.9	3603.8	5405.6	7207.5	9009.4
51	.03	.06	.09	.11	.15	.18	.21	.23	.26	1.8	3.5	5.2	7.0	8.8
52	.03	.05	.08	.10	.14	.16	.19	.22	.24	1.6	3.3	4.8	6.5	8.1
53	.02	.05	.07	.10	.13	.15	.18	.20	.22	1.5	3.0	4.5	5.9	7.5
54	.02	.04	.07	.09	.12	.13	.16	.18	.20	1.3	2.8	4.1	5.4	6.8
13 55	30.02	60.04	90.06	120.08	150.10	180.12	210.15	240.16	270.19	1801.2	3602.5	5403.7	7204.9	9006.2
56	.02	.04	.06	.07	.09	.11	.13	.15	.17	1.1	2.2	3.3	4.4	5.6
57	.02	.03	.05	.06	.08	.10	.12	.13	.15	1.0	2.0	2.9	3.9	4.9
58	.01	.03	.04	.06	.07	.08	.10	.11	.13	0.8	1.7	2.6	3.4	4.3
59	.01	.02	.04	.05	.06	.07	.09	.10	.11	0.7	1.5	2.2	2.9	3.6
13 60	30.01	60.02	90.03	120.04	150.05	180.06	210.07	240.08	270.09	1800.6	3601.2	5401.8	7202.4	9003.0

Lat.		Latitude 13° to 14°—Meridional arcs.						Latitude 13°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
13	00	30.729			1843.73						
	1	9	1	30.73	.73	1	1 843.7	0	1	1 808.1	0.1
	2	9	2	61.46	.74	2	3 687.5		2	3 616.2	0.2
	3	9	3	92.19	.74	3	5 531.2		3	5 424.3	0.5
	4	9	4	122.92	.74	4	7 375.0		4	7 232.4	0.9
13	05	30.729	5	153.65	1843.74	5	9 218.7	0	5	9 040.5	1.5
	6	9	6	184.38	.75	6	11 062.4		6	10 848.6	2.1
	7	9	7	215.11	.75	7	12 906.2		7	12 656.7	2.9
	8	9	8	245.84	.75	8	14 750.0		8	14 464.8	3.8
	9	9	9	276.57	.75	9	16 593.7		9	16 272.9	4.8
13	10	30.729	10	307.30	1843.76	10	18 437.5	0	10	18 081.0	5.9
	11	9	1	338.03	.76	1	20 281.2		15	27 121.5	13.3
	12	9	2	368.76	.76	2	22 125.0		20	36 162.0	23.7
	13	9	3	399.49	.76	3	23 968.8		25	45 202.5	37.0
	14	9	4	430.22	.77	4	25 812.5		30	54 243.0	53.2
13	15	30.729	15	460.95	1843.77	15	27 656.3	0	35	63 283.5	72.5
	16	30	6	491.68	.77	6	29 500.1		40	72 324.0	94.7
	17	0	7	522.41	.77	7	31 343.8		45	81 364.5	119.9
	18	0	8	553.14	.78	8	33 187.6		50	90 405.0	148.0
	19	0	9	583.87	.78	9	35 031.4		55	99 445.4	179.1
13	20	30.730	20	614.60	1843.78	20	36 875.2	1	00	108 485.9	213.0
	21	0	1	645.33	.78	1	38 719.0		05	117 526.3	249.9
	22	0	2	676.06	.79	2	40 562.7		10	126 566.7	289.8
	23	0	3	706.79	.79	3	42 406.5		15	135 607.1	332.7
	24	0	4	737.52	.79	4	44 250.3		20	144 647.5	378.6
13	25	30.730	25	768.25	1843.79	25	46 094.1	1	25	153 687.9	427.4
	26	0	6	798.98	.80	6	47 937.9		30	162 728.3	479.1
	27	0	7	829.71	.80	7	49 781.7		35	171 768.6	533.8
	28	0	8	860.44	.80	8	51 625.5		40	180 809.0	591.6
	29	0	9	891.17	.80	9	53 469.3		45	189 849.2	652.1
13	30	30.730	30	921.90	1843.81	30	55 313.1	1	50	198 889.5	715.7
	31	0	1	952.63	.81	1	57 156.9		55	207 929.6	782.3
	32	0	2	983.36	.81	2	59 000.8	2	00	216 970	852
	33	0	3	1 014.09	.81	3	60 844.6	3	00	325 451	1 917
	34	0	4	1 044.82	.82	4	62 688.4	4	00	433 927	3 407
13	35	30.730	35	1 075.55	1843.82	35	64 532.2	5	00	542 396	5 324
	36	0	6	1 106.28	.82	6	66 376.0	6	00	650 857	7 666
	37	0	7	1 137.01	.82	7	68 219.8	7	00	759 307	10 434
	38	0	8	1 167.74	.83	8	70 063.6	8	00	867 746	13 628
	39	0	9	1 198.47	.83	9	71 907.5	9	00	976 172	17 248
13	40	30.731	40	1 229.21	1843.83	40	73 751.3	10	00	1 084 583	21 294
	41	1	1	1 259.94	.83	1	75 595.1	11	00	1 192 977	25 765
	42	1	2	1 290.67	.84	2	77 439.0	12	00	1 301 352	30 661
	43	1	3	1 321.40	.84	3	79 282.8	13	00	1 409 708	35 983
	44	1	4	1 352.13	.84	4	81 126.7	14	00	1 518 042	41 730
13	45	30.731	45	1 382.86	1843.84	45	82 970.5	15	00	1 626 352	47 903
	46	1	6	1 413.59	.85	6	84 814.3	16	00	1 734 637	54 501
	47	1	7	1 444.32	.85	7	86 658.2	17	00	1 842 896	61 524
	48	1	8	1 475.05	.85	8	88 502.0	18	00	1 951 126	68 972
	49	1	9	1 505.78	.85	9	90 345.9	19	00	2 059 326	76 845
13	50	30.731	50	1 536.51	1843.86	50	92 189.8	20	00	2 167 494	85 143
	51	1	1	1 567.24	.86	1	94 033.6	21	00	2 275 629	93 865
	52	1	2	1 597.97	.86	2	95 877.5	22	00	2 383 729	103 012
	53	1	3	1 628.70	.86	3	97 721.3	23	00	2 491 792	112 583
	54	1	4	1 659.43	.87	4	99 565.2	24	00	2 599 817	122 578
13	55	30.731	55	1 690.16	1843.87	55	101 409.1	25	00	2 707 801	132 997
	56	1	6	1 720.89	.87	6	103 252.9	26	00	2 815 744	143 840
	57	1	7	1 751.62	.87	7	105 096.8	27	00	2 923 644	155 107
	58	1	8	1 782.35	.88	8	106 940.7	28	00	3 031 498	166 798
	59	1	9	1 813.08	.88	9	108 784.6	29	00	3 139 305	178 912
13	60	30.731	60	1 843.81	1843.88	60	110 628.4	30	00	3 247 065	191 448

Latitude 14° to 15°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
14 00	30.01	60.02	90.03	120.04	150.05	180.06	210.07	240.08	270.09	1800.6	3601.2	5401.8	7202.4	9003.0
1	.01	.02	.02	.03	.04	.05	.06	.06	.07	0.5	0.9	1.4	1.9	2.3
2	.01	.01	.02	.02	.03	.03	.04	.04	.05	0.3	0.7	1.0	1.3	1.6
3	.00	.01	.01	.01	.02	.02	.03	.03	.03	0.2	0.4	0.6	0.8	1.0
4	.00	.00	90.00	20.00	50.01	80.01	.01	40.01	70.01	800.1	600.2	400.2	200.2	9000.4
14 05	30.00	60.00	90.00	119.99	149.99	179.99	210.00	239.99	269.99	1799.9	3599.9	5399.8	7199.7	8999.7
6	.00	60.00	89.99	.99	.98	.98	09.98	.97	.97	9.8	9.6	9.4	9.2	9.0
7	30.00	59.99	.98	.98	.97	.97	.97	.95	.95	9.7	9.4	9.0	8.7	8.4
8	29.99	.99	.98	.97	.96	.95	.95	.94	.93	9.5	9.1	8.7	8.1	7.7
9	.99	.98	.97	.96	.95	.94	.94	.92	.91	9.4	8.9	8.3	7.6	7.1
14 10	29.99	59.98	89.96	119.95	149.94	179.93	209.92	239.90	269.89	1799.3	3598.6	5397.9	7197.1	8996.4
11	.99	.98	.96	.94	.93	.92	.90	.88	.87	9.2	8.3	7.5	6.6	5.7
12	.99	.97	.95	.93	.92	.90	.89	.87	.85	9.0	8.0	7.1	6.1	5.1
13	.98	.97	.94	.92	.91	.89	.87	.85	.83	8.9	7.8	6.7	5.5	4.4
14	.98	.96	.94	.91	.90	.88	.86	.83	.81	8.8	7.5	6.3	5.0	3.8
14 15	29.98	59.96	89.93	119.90	149.88	179.86	209.84	239.81	269.79	1798.6	3597.2	5395.9	7194.5	8993.1
16	.98	.95	.92	.90	.87	.85	.82	.80	.77	8.5	6.9	5.5	4.0	2.4
17	.98	.95	.92	.89	.86	.84	.81	.78	.75	8.4	6.7	5.1	3.5	1.8
18	.97	.94	.91	.88	.85	.82	.79	.76	.73	8.2	6.4	4.7	2.9	1.1
19	.97	.94	.91	.87	.84	.81	.78	.75	.71	8.1	6.2	4.3	2.4	90.5
14 20	29.97	59.93	89.90	119.86	149.83	179.80	209.76	239.73	269.69	1798.0	3595.9	5393.9	7191.9	8989.8
21	.97	.93	.89	.85	.82	.79	.75	.71	.67	7.9	5.6	3.5	1.4	9.1
22	.96	.92	.89	.84	.81	.77	.73	.69	.65	7.7	5.4	3.1	0.8	8.5
23	.96	.92	.88	.84	.80	.76	.72	.68	.63	7.6	5.1	2.7	90.3	7.8
24	.96	.91	.87	.83	.79	.74	.70	.66	.61	7.4	4.9	2.3	89.7	7.2
14 25	29.95	59.91	89.86	119.82	149.77	179.73	209.69	239.64	269.59	1797.3	3594.6	5391.9	7189.2	8986.5
26	.95	.91	.86	.81	.76	.72	.67	.62	.57	7.2	4.3	1.5	8.7	5.8
27	.95	.90	.85	.80	.75	.70	.66	.60	.55	7.0	4.1	1.1	8.1	5.1
28	.95	.90	.84	.80	.74	.69	.64	.59	.53	6.9	3.8	0.7	7.6	4.5
29	.94	.89	.84	.79	.73	.67	.63	.57	.51	6.7	3.6	90.3	7.0	3.8
14 30	29.94	59.89	89.83	119.78	149.72	179.66	209.61	239.55	269.49	1796.6	3593.3	5389.9	7186.5	8983.1
31	.94	.89	.82	.77	.71	.65	.59	.53	.47	6.5	3.0	9.5	6.0	2.4
32	.94	.88	.82	.76	.70	.64	.58	.51	.45	6.4	2.7	9.1	5.4	1.8
33	.93	.88	.81	.75	.69	.62	.56	.50	.43	6.2	2.5	8.7	4.9	1.1
34	.93	.87	.80	.74	.68	.61	.55	.48	.41	6.1	2.2	8.3	4.3	80.5
14 35	29.93	59.87	89.80	119.73	149.66	179.60	209.53	239.46	269.39	1796.0	3591.9	5387.9	7183.8	8979.8
36	.93	.86	.79	.73	.65	.58	.51	.44	.37	5.8	1.6	7.5	3.3	9.1
37	.93	.86	.78	.72	.64	.57	.50	.42	.35	5.7	1.4	7.1	2.7	8.4
38	.92	.85	.78	.71	.63	.56	.48	.41	.33	5.6	1.1	6.6	2.2	7.8
39	.92	.85	.77	.70	.62	.54	.47	.39	.31	5.4	0.9	6.2	1.6	7.1
14 40	29.92	59.84	89.76	119.69	149.61	179.53	209.45	239.37	269.29	1795.3	3590.6	5385.8	7181.1	8976.4
41	.92	.84	.76	.68	.60	.52	.43	.35	.27	5.2	0.3	5.4	0.6	5.7
42	.92	.83	.75	.67	.59	.50	.42	.33	.25	5.0	90.0	5.0	80.0	5.0
43	.91	.83	.74	.66	.57	.49	.40	.32	.23	4.9	89.8	4.5	79.5	4.4
44	.91	.82	.74	.65	.56	.47	.39	.30	.21	4.7	9.5	4.1	8.9	3.7
14 45	29.91	59.82	89.73	119.64	149.55	179.46	209.37	239.28	269.19	1794.6	3589.2	5383.7	7178.4	8973.0
46	.91	.82	.72	.63	.54	.45	.35	.26	.17	4.5	8.9	3.3	7.9	2.3
47	.91	.81	.72	.62	.53	.43	.34	.24	.15	4.3	8.6	2.9	7.3	1.6
48	.90	.81	.71	.61	.51	.42	.32	.23	.13	4.2	8.4	2.5	6.8	1.0
49	.90	.80	.70	.60	.50	.40	.31	.21	.11	4.0	8.1	2.1	6.2	70.3
14 50	29.90	59.80	89.70	119.59	149.49	179.39	209.29	239.19	269.09	1793.9	3587.8	5381.7	7175.7	8969.6
51	.90	.80	.69	.58	.48	.38	.27	.17	.07	3.8	7.5	1.3	5.1	8.9
52	.90	.79	.68	.57	.47	.36	.26	.15	.05	3.6	7.2	0.9	4.6	8.2
53	.89	.79	.68	.56	.46	.35	.24	.13	.03	3.5	7.0	0.5	4.0	7.5
54	.89	.78	.67	.55	.45	.33	.23	.11	9.01	3.3	6.7	80.1	3.5	6.8
14 55	29.89	59.78	89.66	119.54	149.43	179.32	209.21	239.09	268.98	1793.2	3586.4	5379.7	7172.9	8966.1
56	.89	.77	.65	.54	.42	.31	.19	.08	.96	3.1	6.1	9.3	2.3	5.4
57	.89	.77	.65	.53	.41	.29	.18	.06	.94	2.9	5.9	8.9	1.8	4.7
58	.88	.76	.64	.52	.40	.28	.16	.04	.92	2.8	5.6	8.4	1.2	4.1
59	.88	.76	.63	.51	.39	.26	.15	.02	.90	2.6	5.4	8.0	0.7	3.4
14 60	29.88	59.75	89.63	119.50	149.38	179.25	209.13	239.00	268.88	1792.5	3585.1	5377.6	7170.1	8962.7

Lat.		Latitude 14° to 15°—Meridional arcs.						Latitude 14°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
14	00	30.731			1843.88						
	1	1	1	30.73	.88	1	1 843.9	0	1	1 800.6	0.1
	2	1	2	61.47	.89	2	3 687.8		2	3 601.2	0.3
	3	1	3	92.20	.89	3	5 531.7		3	5 401.8	0.6
	4	2	4	122.93	.89	4	7 375.6		4	7 202.4	1.0
14	05	30.732	5	153.66	1843.89	5	9 219.4	0	5	9 002.9	1.6
	6	2	6	184.40	.90	6	11 063.3		6	10 803.5	2.3
	7	2	7	215.13	.90	7	12 907.2		7	12 604.1	3.1
	8	2	8	245.86	.90	8	14 751.1		8	14 404.7	4.1
	9	2	9	276.59	.91	9	16 595.0		9	16 205.3	5.1
14	10	30.732	10	307.33	1843.91	10	18 438.9	0	10	18 005.9	6.3
	11	2	1	338.06	.91	1	20 282.9		15	27 008.8	14.2
	12	2	2	368.79	.91	2	22 126.8		20	36 011.8	25.3
	13	2	3	399.52	.92	3	23 970.7		25	45 014.7	39.6
	14	2	4	430.26	.92	4	25 814.6		30	54 017.7	57.0
14	15	30.732	15	460.99	1843.92	15	27 658.5	0	35	63 020.6	77.6
	16	2	6	491.72	.92	6	29 502.5		40	72 023.5	101.4
	17	2	7	522.46	.93	7	31 346.4		45	81 026.4	128.3
	18	2	8	553.19	.93	8	33 190.3		50	90 029.3	158.4
	19	2	9	583.92	.93	9	35 034.3		55	99 032.2	191.7
14	20	30.732	20	614.65	1843.93	20	36 878.2	1	00	108 035.1	228.1
	21	2	1	645.39	.94	1	38 722.1		05	117 037.9	267.7
	22	2	2	676.12	.94	2	40 566.1		10	126 040.8	310.4
	23	2	3	706.85	.94	3	42 410.0		15	135 043.6	356.4
	24	2	4	737.58	.94	4	44 254.0		20	144 046.4	405.5
14	25	30.732	25	768.32	1843.95	25	46 097.9	1	25	153 049.2	457.7
	26	2	6	799.05	.95	6	47 941.9		30	162 052.0	513.2
	27	3	7	829.78	.95	7	49 785.8		35	171 054.8	571.8
	28	3	8	860.52	.96	8	51 629.8		40	180 057.5	633.6
	29	3	9	891.25	.96	9	53 473.7		45	189 060.2	698.5
14	30	30.733	30	921.98	1843.96	30	55 317.7	1	50	198 062.9	766.6
	31	3	1	952.71	.96	1	57 161.6		55	207 065.6	837.9
	32	3	2	983.45	.97	2	59 005.6	2	00	216 068	912
	33	3	3	1 014.18	.97	3	60 849.5	3	00	324 098	2 053
	34	3	4	1 044.91	.97	4	62 693.5	4	00	432 121	3 649
14	35	30.733	35	1 075.64	1843.97	35	64 537.5	5	00	540 137	5 702
	36	3	6	1 106.38	.98	6	66 381.5	6	00	648 143	8 210
	37	3	7	1 137.11	.98	7	68 225.4	7	00	756 138	11 175
	38	3	8	1 167.84	.98	8	70 069.4	8	00	864 119	14 595
	39	3	9	1 198.57	.98	9	71 913.4	9	00	972 085	18 472
14	40	30.733	40	1 229.31	1843.99	40	73 757.4	10	00	1 080 033	22 805
	41	3	1	1 260.04	.99	1	75 601.4	11	00	1 187 962	27 593
	42	3	2	1 290.77	.99	2	77 445.4	12	00	1 295 870	32 857
	43	3	3	1 321.51	3.99	3	79 289.4	13	00	1 403 755	38 536
	44	3	4	1 352.24	4.00	4	81 133.4	14	00	1 511 615	44 691
14	45	30.733	45	1 382.97	1844.00	45	82 977.3	15	00	1 619 448	51 301
	46	3	6	1 413.70	.00	6	84 821.4	16	00	1 727 252	58 366
	47	3	7	1 444.44	.00	7	86 665.4	17	00	1 835 025	65 887
	48	3	8	1 475.17	.01	8	88 509.4	18	00	1 942 766	73 863
	49	3	9	1 505.90	.01	9	90 353.4	19	00	2 050 472	82 294
14	50	30.734	50	1 536.63	1844.01	50	92 197.4	20	00	2 158 142	91 179
	51	4	1	1 567.37	.01	1	94 041.4	21	00	2 265 772	100 518
	52	4	2	1 598.10	.02	2	95 885.4	22	00	2 373 362	110 312
	53	4	3	1 628.83	.02	3	97 729.4	23	00	2 480 911	120 560
	54	4	4	1 659.57	.02	4	99 573.5	24	00	2 588 415	131 262
14	55	30.734	55	1 690.30	1844.02	55	101 417.5	25	00	2 695 873	142 418
	56	4	6	1 721.03	.03	6	103 261.5	26	00	2 803 283	154 028
	57	4	7	1 751.76	.03	7	105 105.5	27	00	2 910 642	166 091
	58	4	8	1 782.50	.03	8	106 949.6	28	00	3 017 950	178 607
	59	4	9	1 813.23	.04	9	108 793.6	29	00	3 125 204	191 576
14	60	30.734	60	1 843.96	1844.04	60	110 637.6	30	00	3 232 402	204 998

Latitude 15° to 16°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
15 00	29.88	59.75	89.63	119.50	149.38	179.25	209.13	239.00	268.88	1792.5	3585.1	5377.6	7170.1	8962.7
1	.88	.75	.62	.49	.37	.24	.11	8.98	.86	2.4	4.8	7.2	69.6	2.0
2	.87	.74	.61	.48	.36	.22	.10	.96	.84	2.2	4.5	6.8	9.0	1.3
3	.87	.74	.61	.47	.34	.21	.08	.95	.82	2.1	4.3	6.3	8.4	60.6
4	.87	.73	.60	.46	.33	.19	.07	.93	.80	1.9	4.0	5.9	7.9	59.9
15 05	29.86	59.73	89.59	119.45	149.32	179.18	209.05	238.91	268.77	1791.8	3583.7	5375.5	7167.3	8959.2
6	.86	.72	.59	.45	.31	.17	.03	.89	.75	1.7	3.4	5.1	6.8	8.5
7	.86	.72	.58	.44	.30	.15	.02	.87	.73	1.5	3.1	4.7	6.2	7.8
8	.86	.71	.57	.43	.28	.14	9.00	.86	.71	1.4	2.9	4.2	5.7	7.1
9	.85	.71	.56	.42	.27	.12	8.99	.84	.69	1.2	2.6	3.8	5.1	6.4
15 10	29.85	59.70	89.56	119.41	149.26	179.11	208.97	238.82	268.67	1791.1	3582.3	5373.4	7164.6	8955.7
11	.85	.70	.55	.40	.25	.10	.95	.80	.65	1.0	2.0	3.0	4.0	5.0
12	.85	.69	.54	.39	.24	.08	.94	.78	.63	0.8	1.7	2.6	3.4	4.3
13	.84	.69	.54	.38	.22	.07	.92	.76	.61	0.7	1.5	2.1	2.9	3.6
14	.84	.68	.53	.37	.21	.05	.90	.74	.59	0.5	1.2	1.7	2.3	2.9
15 15	29.84	59.68	89.52	119.36	149.20	179.04	208.89	238.72	268.56	1790.4	3580.9	5371.3	7161.7	8952.2
16	.84	.68	.52	.35	19	.03	.87	.71	.54	0.3	0.6	0.9	1.1	1.5
17	.84	.67	.51	.34	.18	.01	.85	.69	.52	0.1	0.3	0.5	0.6	0.8
18	.83	.67	.50	.33	.16	9.00	.83	.67	.50	90.0	80.0	70.0	60.0	50.0
19	.83	.66	.49	.32	.15	8.98	.82	.65	.48	89.8	79.7	69.6	59.5	49.3
15 20	29.83	59.66	89.49	119.31	149.14	178.97	208.80	238.63	268.46	1789.7	3579.4	5369.2	7158.9	8948.6
21	.83	.66	.48	.30	.13	.96	.78	.61	.44	9.6	9.1	8.8	8.3	7.9
22	.83	.65	.47	.29	.12	.94	.77	.59	.42	9.4	8.8	8.3	7.7	7.2
23	.82	.65	.46	.28	.11	.93	.75	.57	.40	9.3	8.6	7.9	7.2	6.4
24	.82	.64	.46	.27	.10	.91	.74	.55	.38	9.1	8.3	7.4	6.6	5.7
15 25	29.82	59.64	89.45	119.26	149.08	178.90	208.72	238.54	268.35	1789.0	3578.0	5367.0	7156.0	8945.0
26	.82	.63	.44	.26	.07	.89	.70	.52	.33	8.9	7.7	6.6	5.4	4.3
27	.82	.63	.44	.25	.06	.87	.69	.50	.31	8.7	7.4	6.2	4.9	3.6
28	.81	.62	.43	.24	.05	.86	.67	.48	.29	8.6	7.2	5.7	4.3	2.9
29	.81	.62	.42	.23	.04	.84	.66	.46	.27	8.4	6.9	5.3	3.8	2.2
15 30	29.81	59.61	89.42	119.22	149.03	178.83	208.64	238.44	268.25	1788.3	3576.6	5364.9	7153.2	8941.5
31	.81	.61	.41	.21	.02	.82	.62	.42	.23	8.2	6.3	4.5	2.6	0.8
32	.80	.60	.40	.20	9.01	.80	.61	.40	.21	8.0	6.0	4.0	2.0	40.1
33	.80	.60	.39	.19	8.99	.79	.59	.38	.18	7.9	5.8	3.6	1.5	39.3
34	.80	.59	.39	.18	.98	.77	.57	.36	.16	7.7	5.5	3.1	0.9	8.6
15 35	29.79	59.59	89.38	119.17	148.97	178.76	208.55	238.35	268.14	1787.6	3575.2	5362.7	7150.3	8937.9
36	.79	.58	.37	.16	.96	.75	.54	.33	.12	7.5	4.9	2.3	49.7	7.2
37	.79	.58	.36	.15	.95	.73	.52	.31	.10	7.3	4.6	1.9	9.1	6.5
38	.79	.57	.36	.14	.93	.72	.50	.29	.07	7.2	4.3	1.4	8.6	5.7
39	.78	.57	.35	.13	.92	.70	.49	.27	.05	7.0	4.0	1.0	8.0	5.0
15 40	29.78	59.56	89.34	119.12	148.91	178.69	208.47	238.25	268.03	1786.9	3573.7	5360.6	7147.4	8934.3
41	.78	.56	.34	.11	.90	.67	.45	.23	8.01	6.7	3.4	60.2	6.8	3.6
42	.78	.55	.33	.10	.88	.66	.44	.21	7.99	6.6	3.1	59.7	6.2	2.8
43	.77	.55	.32	.09	.87	.64	.42	.19	.96	6.4	2.9	9.3	5.7	2.1
44	.77	.54	.31	.08	.86	.63	.40	.17	.94	6.3	2.6	8.8	5.1	1.3
15 45	29.77	59.54	89.31	119.07	148.84	178.61	208.39	238.15	267.92	1786.1	3572.3	5358.4	7144.5	8930.6
46	.77	.53	.30	.07	.83	.60	.37	.13	.90	6.0	2.0	8.0	3.9	29.9
47	.77	.53	.29	.06	.82	.58	.35	.11	.88	5.8	1.7	7.5	3.3	9.2
48	.76	.52	.28	.05	.81	.57	.33	.09	.85	5.7	1.4	7.1	2.8	8.4
49	.76	.52	.28	.04	.79	.55	.32	.07	.83	5.5	1.1	6.6	2.2	7.7
15 50	29.76	59.51	89.27	119.03	148.78	178.54	208.30	238.05	267.81	1785.4	3570.8	5356.2	7141.6	8927.0
51	.76	.51	.26	.02	.77	.53	.28	.03	.79	5.3	0.5	5.8	1.0	6.3
52	.75	.50	.26	.01	.76	.51	.27	8.01	.77	5.1	70.2	5.3	40.4	5.5
53	.75	.50	.25	9.00	.74	.50	.25	7.99	.74	5.0	69.9	4.9	39.9	4.8
54	.75	.49	.24	8.99	.73	.48	.23	.97	.72	4.8	9.6	4.4	9.3	4.0
15 55	29.74	59.49	89.23	118.98	148.72	178.47	208.22	237.96	267.70	1784.7	3569.3	5354.0	7138.7	8923.3
56	.74	.48	.23	.97	.71	.45	.20	.94	.68	4.5	9.0	3.6	8.1	2.6
57	.74	.48	.22	.96	.70	.44	.18	.92	.66	4.4	8.7	3.1	7.5	1.9
58	.74	.47	.21	.95	.68	.42	.16	.90	.63	4.2	8.5	2.7	6.9	1.1
59	.73	.47	.20	.94	.67	.41	.15	.88	.61	4.1	8.2	2.2	6.3	20.4
15 60	29.73	59.46	89.20	118.93	148.66	178.39	208.13	237.86	267.59	1783.9	3567.9	5551.8	7135.7	8919.7

Lat.	Latitude 15° to 16°—Meridional arcs.						Latitude 15°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
15 00	30.734			1844.04					
1	4	1	30.74	.04	1	1 844.0	0 1	1 792.5	0.1
2	4	2	61.47	.05	2	3 688.1	2	3 585.1	0.3
3	4	3	92.21	.05	3	5 532.1	3	5 377.6	0.6
4	4	4	122.94	.05	4	7 376.2	4	7 170.1	1.1
15 05	30.734	5	153.68	1844.05	5	9 220.2	0 5	8 962.7	1.7
6	4	6	184.41	.06	6	11 064.3	6	10 755.2	2.4
7	4	7	215.15	.06	7	12 908.4	7	12 547.7	3.3
8	4	8	245.88	.06	8	14 752.4	8	14 340.2	4.3
9	4	9	276.62	.06	9	16 596.5	9	16 132.8	5.5
15 10	30.734	10	307.35	1844.07	10	18 440.6	0 10	17 925.3	6.8
11	5	1	338.09	.07	1	20 284.6	15	26 887.9	15.2
12	5	2	368.82	.07	2	22 128.7	20	35 850.6	27.0
13	5	3	399.56	.08	3	23 972.8	25	44 813.2	42.2
14	5	4	430.30	.08	4	25 816.9	30	53 775.9	60.7
15 15	30.735	15	461.03	1844.08	15	27 660.9	0 35	62 738.5	82.7
16	5	6	491.77	.08	6	29 505.0	40	71 701.2	108.0
17	5	7	522.50	.09	7	31 349.1	45	80 663.8	136.7
18	5	8	553.24	.09	8	33 193.2	50	89 626.4	168.7
19	5	9	583.97	.09	9	35 037.3	55	98 589.0	204.1
15 20	30.735	20	614.71	1844.10	20	36 881.4	1 00	107 551.6	242.9
21	5	1	645.44	.10	1	38 725.5	05	116 514.1	285.1
22	5	2	676.18	.10	2	40 569.6	10	125 476.6	330.7
23	5	3	706.91	.10	3	42 413.7	15	134 439.2	379.6
24	5	4	737.65	.11	4	44 257.8	20	143 401.7	431.9
15 25	30.735	25	768.39	1844.11	25	46 101.9	1 25	152 364.2	487.5
26	5	6	799.12	.11	6	47 946.0	30	161 326.6	546.6
27	5	7	829.86	.12	7	49 790.1	35	170 289.1	609.0
28	5	8	860.59	.12	8	51 634.3	40	179 251.5	674.8
29	5	9	891.33	.12	9	53 478.4	45	188 213.9	743.9
15 30	30.735	30	922.06	1844.12	30	55 322.5	1 50	197 176.3	816.5
31	5	1	952.80	.13	1	57 166.6	55	206 138.6	892.4
32	5	2	983.53	.13	2	59 010.8	2 00	215 101	972
33	6	3	1 014.27	.13	3	60 854.9	3 00	322 646	2 186
34	6	4	1 045.00	.13	4	62 699.0	4 00	430 184	3 887
15 35	30.736	35	1 075.74	1844.14	35	64 543.2	5 00	537 713	6 072
36	6	6	1 106.47	.14	6	66 387.3	6 00	645 232	8 744
37	6	7	1 137.21	.14	7	68 231.4	7 00	752 738	11 901
38	6	8	1 167.95	.15	8	70 075.6	8 00	860 228	15 545
39	6	9	1 198.68	.15	9	71 919.7	9 00	967 701	19 674
15 40	30.736	40	1 229.42	1844.15	40	73 763.9	10 00	1 075 153	24 288
41	6	1	1 260.15	.15	1	75 608.0	11 00	1 182 584	29 387
42	6	2	1 290.89	.16	2	77 452.2	12 00	1 289 991	34 972
43	6	3	1 321.62	.16	3	79 296.3	13 00	1 397 371	41 042
44	6	4	1 352.36	.16	4	81 140.5	14 00	1 504 723	47 597
15 45	30.736	45	1 383.09	1844.17	45	82 984.6	15 00	1 612 046	54 636
46	6	6	1 413.83	.17	6	84 828.8	16 00	1 719 333	62 160
47	6	7	1 444.56	.17	7	86 673.0	17 00	1 826 586	70 169
48	6	8	1 475.30	.17	8	88 517.2	18 00	1 933 802	78 662
49	6	9	1 506.03	.18	9	90 361.3	19 00	2 040 978	87 639
15 50	30.736	50	1 536.77	1844.18	50	92 205.5	20 00	2 148 113	97 101
51	6	1	1 567.51	.18	1	94 049.7	21 00	2 255 204	107 047
52	6	2	1 598.24	.19	2	95 893.9	22 00	2 362 248	117 476
53	6	3	1 628.98	.19	3	97 738.1	23 00	2 469 245	128 388
54	7	4	1 659.71	.19	4	99 582.3	24 00	2 576 192	139 784
15 55	30.737	55	1 690.45	1844.19	55	101 426.5	25 00	2 683 086	151 663
56	7	6	1 721.18	.20	6	103 270.6	26 00	2 789 925	164 024
57	7	7	1 751.92	.20	7	105 114.8	27 00	2 896 708	176 868
58	7	8	1 782.65	.20	8	106 959.0	28 00	3 003 430	190 194
59	7	9	1 813.39	.20	9	108 803.3	29 00	3 110 091	204 003
15 60	30.737	60	1 844.12	1844.21	60	110 647.5	30 00	3 216 690	218 294

Latitude 16° to 17°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
16 00	29.73	59.46	89.20	118.93	148.66	178.39	208.13	237.86	267.59	1783.9	3567.9	5351.8	7135.7	8919.7
1	.73	.46	.19	.92	.65	.38	.11	.84	.57	3.8	7.6	1.4	5.1	8.9
2	.73	.45	.18	.91	.64	.36	.09	.82	.55	3.6	7.3	0.9	4.5	8.2
3	.72	.45	.17	.90	.62	.35	.08	.80	.53	3.5	7.0	0.5	3.9	7.4
4	.72	.44	.17	.89	.61	.33	.06	.78	.51	3.3	6.7	50.0	3.3	6.7
16 05	29.72	59.44	89.16	118.88	148.60	178.32	208.04	237.76	267.48	1783.2	3566.4	5349.6	7132.7	8915.9
6	.72	.43	.15	.87	.59	.30	.02	.74	.46	3.0	6.1	9.1	2.1	5.2
7	.72	.43	.14	.86	.58	.29	8.00	.72	.44	2.9	5.8	8.7	1.5	4.4
8	.71	.42	.14	.85	.56	.27	7.99	.70	.41	2.7	5.5	8.2	1.0	3.7
9	.71	.42	.13	.84	.55	.26	.97	.68	.39	2.6	5.2	7.8	30.4	2.9
16 10	29.71	59.41	89.12	118.83	148.54	178.24	207.95	237.66	267.37	1782.4	3564.9	5347.3	7129.8	8912.2
11	.71	.41	.11	.82	.53	.23	.93	.64	.35	2.3	4.6	6.9	9.2	1.5
12	.70	.40	.11	.81	.51	.21	.92	.62	.32	2.1	4.3	6.4	8.6	0.7
13	.70	.40	.10	.80	.50	.20	.90	.60	.30	2.0	4.0	6.0	8.0	10.0
14	.70	.39	.09	.79	.49	.18	.88	.58	.28	1.8	3.7	5.5	7.4	09.2
16 15	29.69	59.39	89.08	118.78	148.47	178.17	207.87	237.56	267.26	1781.7	3563.4	5345.1	7126.8	8908.5
16	.69	.38	.08	.77	.46	.15	.85	.54	.23	1.5	3.1	4.6	6.2	7.7
17	.69	.38	.07	.76	.45	.14	.83	.52	.21	1.4	2.8	4.2	5.6	7.0
18	.69	.37	.06	.75	.44	.12	.81	.50	.19	1.2	2.5	3.7	5.0	6.2
19	.68	.37	.06	.74	.42	.11	.80	.48	.16	1.1	2.2	3.3	4.4	5.5
16 20	29.68	59.36	89.05	118.73	148.41	178.09	207.78	237.46	267.14	1780.9	3561.9	5342.8	7123.8	8904.7
21	.68	.36	.04	.72	.40	.08	.76	.44	.12	0.8	1.6	2.4	3.2	3.9
22	.68	.35	.03	.71	.39	.06	.74	.42	.09	0.6	1.3	1.9	2.6	3.1
23	.67	.35	.02	.70	.37	.05	.73	.40	.07	0.5	1.0	1.5	1.9	2.4
24	.67	.34	.02	.69	.36	.03	.71	.38	.05	0.3	0.7	1.0	1.3	1.6
16 25	29.67	59.34	89.01	118.68	148.35	178.02	207.69	237.36	267.02	1780.2	3560.4	5340.6	7120.7	8900.8
26	.67	.33	9.00	.67	.34	8.00	.67	.34	7.00	80.0	60.1	40.1	20.1	900.0
27	.67	.33	8.99	.66	.33	7.99	.65	.32	6.98	79.9	59.8	39.7	19.5	899.3
28	.66	.32	.99	.65	.31	.97	.64	.30	.96	9.7	9.5	9.2	8.9	8.6
29	.66	.32	.98	.64	.30	.96	.62	.28	.93	9.6	9.2	8.8	8.3	7.9
16 30	29.66	59.31	88.97	118.63	148.29	177.94	207.60	237.26	266.91	1779.4	3558.9	5338.3	7117.7	8897.1
31	.66	.31	.96	.62	.28	.93	.58	.24	.89	9.3	8.6	7.8	7.1	6.3
32	.65	.30	.96	.61	.26	.91	.56	.22	.86	9.1	8.3	7.4	6.5	5.6
33	.65	.30	.95	.60	.25	.90	.55	.20	.84	9.0	7.9	6.9	5.8	4.8
34	.65	.29	.94	.59	.24	.88	.53	.18	.82	8.8	7.6	6.5	5.2	4.1
16 35	29.64	59.29	88.93	118.58	148.22	177.87	207.51	237.15	266.79	1778.7	3557.3	5336.0	7114.6	8893.3
36	.64	.28	.92	.57	.21	.85	.49	.13	.77	8.5	7.0	5.5	4.0	2.5
37	.64	.28	.92	.56	.20	.84	.47	.11	.75	8.4	6.7	5.1	3.4	1.8
38	.64	.27	.91	.55	.19	.82	.46	.09	.73	8.2	6.4	4.6	2.8	1.0
39	.63	.27	.90	.54	.17	.81	.44	.07	.70	8.1	6.1	4.2	2.2	90.3
16 40	29.63	59.26	88.89	118.53	148.16	177.79	207.42	237.05	266.68	1777.9	3555.8	5333.7	7111.6	8889.5
41	.63	.26	.89	.52	.15	.77	.40	.03	.66	7.7	5.5	3.2	1.0	8.7
42	.63	.25	.88	.51	.13	.76	.38	7.01	.63	7.6	5.2	2.8	10.4	7.9
43	.62	.25	.87	.50	.12	.74	.37	6.99	.61	7.4	4.8	2.3	09.7	7.2
44	.62	.24	.86	.49	.11	.73	.35	.97	.59	7.3	4.5	1.9	9.1	6.4
16 45	29.62	59.24	88.86	118.47	148.09	177.71	207.33	236.95	266.56	1777.1	3554.2	5331.4	7108.5	8885.6
46	.62	.23	.85	.46	.08	.70	.31	.93	.54	7.0	3.9	0.9	7.9	4.8
47	.62	.23	.84	.45	.07	.68	.29	.91	.52	6.8	3.6	0.5	7.3	4.1
48	.61	.22	.83	.44	.06	.67	.28	.89	.50	6.7	3.3	30.0	6.6	3.3
49	.61	.22	.83	.43	.04	.65	.26	.87	.47	6.5	3.0	29.6	6.0	2.6
16 50	29.61	59.21	88.82	118.42	148.03	177.64	207.24	236.85	266.45	1776.4	3552.7	5329.1	7105.4	8881.8
51	.61	.21	.81	.41	.02	.62	.22	.83	.43	6.2	2.4	8.6	4.8	1.0
52	.60	.20	.80	.40	8.00	.61	.20	.81	.40	6.1	2.1	8.1	4.2	80.2
53	.60	.20	.79	.39	7.99	.59	.19	.79	.38	5.9	1.7	7.7	3.5	79.4
54	.60	.19	.79	.38	.98	.58	.17	.77	.36	5.8	1.4	7.2	2.9	8.6
16 55	29.59	59.19	88.78	118.37	147.96	177.56	207.15	236.74	266.33	1775.6	3551.1	5326.7	7102.3	8877.8
56	.59	.18	.77	.36	.95	.54	.13	.72	.31	5.4	0.8	6.2	1.7	7.0
57	.59	.18	.76	.35	.94	.53	.11	.70	.29	5.3	0.5	5.8	1.1	6.2
58	.59	.17	.76	.34	.93	.51	.10	.68	.27	5.1	50.2	5.3	100.4	5.5
59	.58	.17	.75	.33	.91	.50	.08	.66	.24	5.0	49.9	4.9	099.8	4.7
16 60	29.58	59.16	88.74	118.32	147.90	177.48	207.06	236.64	266.22	1774.8	3549.6	5324.4	7099.2	8873.9

Lat.		Latitude 16° to 17°—Meridional arcs.						Latitude 16°—Co-ordinates of curvature.		
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
16	00	30.737			1844.21					
	1	7	1	30.74	.21	1	1 844.2	0 1	1 783.9	0.1
	2	7	2	61.48	.21	2	3 688.4	2	3 567.9	0.3
	3	7	3	92.21	.22	3	5 532.6	3	5 351.8	0.6
	4	7	4	122.95	.22	4	7 376.9	4	7 135.7	1.1
16	05	30.737	5	153.69	1844.22	5	9 221.1	0 5	8 919.7	1.8
	6	7	6	184.43	.23	6	11 065.3	6	10 703.6	2.6
	7	7	7	215.17	.23	7	12 909.5	7	12 487.5	3.5
	8	7	8	245.91	.23	8	14 753.7	8	14 271.4	4.6
	9	7	9	276.64	.23	9	16 598.0	9	16 055.4	5.8
16	10	30.737	10	307.38	1844.24	10	18 442.2	0 10	17 839.3	7.2
	11	7	1	338.12	.24	1	20 286.5	15	26 758.9	16.1
	12	7	2	368.86	.24	2	22 130.7	20	35 678.6	28.6
	13	7	3	399.60	.25	3	23 975.0	25	44 598.2	44.7
	14	7	4	430.34	.25	4	25 819.2	30	53 517.9	64.4
16	15	30.738	15	461.07	1844.25	15	27 663.5	0 35	62 437.5	87.6
	16	8	6	491.81	.26	6	29 507.7	40	71 357.1	114.4
	17	8	7	522.55	.26	7	31 352.0	45	80 276.7	144.8
	18	8	8	553.29	.26	8	33 196.3	50	89 196.3	178.8
	19	8	9	584.03	.26	9	35 040.5	55	98 115.9	216.4
16	20	30.738	20	614.77	1844.27	20	36 884.8	1 00	107 035.4	257.5
	21	8	1	645.50	.27	1	38 729.1	05	115 955.0	302.2
	22	8	2	676.24	.27	2	40 573.3	10	124 874.5	350.4
	23	8	3	706.98	.28	3	42 417.6	15	133 794.0	402.3
	24	8	4	737.72	.28	4	44 261.9	20	142 713.5	457.7
16	25	30.738	25	768.46	1844.28	25	46 106.2	1 25	151 633.0	516.7
	26	8	6	799.20	.28	6	47 950.5	30	160 552.4	579.3
	27	8	7	829.93	.29	7	49 794.7	35	169 471.8	645.4
	28	8	8	860.67	.29	8	51 639.0	40	178 391.2	715.2
	29	8	9	891.41	.29	9	53 483.3	45	187 310.5	788.5
16	30	30.738	30	922.15	1844.30	30	55 327.6	1 50	196 229.8	865.4
	31	8	1	952.89	.30	1	57 171.9	55	205 149.1	945.8
	32	8	2	983.63	.30	2	59 016.2	2 00	214 068	1 030
	33	8	3	1 014.36	.31	3	60 860.5	3 00	321 097	2 317
	34	8	4	1 045.10	.31	4	62 704.8	4 00	428 117	4 119
16	35	30.739	35	1 075.84	1844.31	35	64 549.2	5 00	535 127	6 436
	36	9	6	1 106.58	.31	6	66 393.5	6 00	642 126	9 268
	37	9	7	1 137.32	.32	7	68 237.8	7 00	749 110	12 614
	38	9	8	1 168.06	.32	8	70 082.1	8 00	856 075	16 476
	39	9	9	1 198.79	.32	9	71 926.4	9 00	963 022	20 852
16	40	30.739	40	1 229.53	1844.33	40	73 770.8	10 00	1 069 946	25 741
	41	9	1	1 260.27	.33	1	75 615.1	11 00	1 176 845	31 145
	42	9	2	1 291.01	.33	2	77 459.4	12 00	1 283 717	37 064
	43	9	3	1 321.75	.34	3	79 303.8	13 00	1 390 559	43 497
	44	9	4	1 352.48	.34	4	81 148.1	14 00	1 497 369	50 444
16	45	30.739	45	1 383.22	1844.34	45	82 992.4	15 00	1 604 146	57 904
	46	9	6	1 413.96	.34	6	84 836.8	16 00	1 710 883	65 878
	47	9	7	1 444.70	.35	7	86 681.1	17 00	1 817 582	74 365
	48	9	8	1 475.44	.35	8	88 525.5	18 00	1 924 239	83 366
	49	9	9	1 506.18	.35	9	90 369.8	19 00	2 030 851	92 880
16	50	30.739	50	1 536.91	1844.36	50	92 214.2	20 00	2 137 416	102 906
	51	9	1	1 567.65	.36	1	94 058.5	21 00	2 243 932	113 445
	52	9	2	1 598.39	.36	2	95 902.9	22 00	2 350 395	124 496
	53	9	3	1 629.13	.36	3	97 747.2	23 00	2 456 804	136 059
	54	39	4	1 659.87	.37	4	99 591.6	24 00	2 563 157	148 134
16	55	30.740	55	1 690.61	1844.37	55	101 436.0	25 00	2 669 451	160 720
	56	0	6	1 721.34	.37	6	103 280.3	26 00	2 775 682	173 818
	57	0	7	1 752.08	.38	7	105 124.7	27 00	2 881 849	187 427
	58	0	8	1 782.82	.38	8	106 969.1	28 00	2 987 949	201 546
	59	0	9	1 813.56	.38	9	108 813.5	29 00	3 093 980	216 175
16	60	30.740	60	1 844.30	1844.39	60	110 657.8	30 00	3 199 941	231 315

Latitude 17° to 18°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
17 00	29.58	59.16	88.74	118.32	147.90	177.48	207.06	236.64	266.22	1774.8	3549.6	5324.4	7099.2	8873.9
1	.58	.16	.73	.31	.89	.46	.04	.62	.20	4.6	9.3	3.9	8.6	3.1
2	.57	.15	.72	.30	.87	.45	.02	.60	.17	4.5	9.0	3.4	7.9	2.3
3	.57	.15	.72	.29	.86	.43	7.01	.58	.15	4.3	8.6	3.0	7.3	1.6
4	.57	.14	.71	.28	.85	.42	6.99	.56	.12	4.2	8.3	2.5	6.6	0.8
17 05	29.56	59.14	88.70	118.26	147.83	177.40	206.97	236.53	266.10	1774.0	3548.0	5322.0	7096.0	8870.0
6	.56	.13	.69	.25	.82	.38	.95	.51	.08	3.8	7.7	1.5	5.4	69.2
7	.56	.13	.68	.24	.81	.37	.93	.49	.05	3.7	7.4	1.0	4.8	8.4
8	.56	.12	.68	.23	.80	.35	.92	.47	.03	3.5	7.0	0.6	4.1	7.7
9	.55	.12	.67	.22	.78	.34	.90	.45	6.00	3.4	6.7	20.1	3.5	6.9
17 10	29.55	59.11	88.66	118.21	147.77	177.32	206.88	236.43	5.98	1773.2	3546.4	5319.6	7092.9	8866.1
11	.55	.10	.65	.20	.76	.30	.86	.41	.96	3.0	6.1	9.1	2.3	5.3
12	.55	.10	.64	.19	.74	.29	.84	.39	.93	2.9	5.8	8.7	1.6	4.5
13	.54	.09	.64	.18	.73	.27	.82	.37	.91	2.7	5.4	8.2	1.0	3.7
14	.54	.09	.63	.17	.72	.26	.80	.35	.88	2.6	5.1	7.8	90.3	2.9
17 15	29.54	59.08	88.62	118.16	147.70	177.24	206.79	236.32	265.86	1772.4	3544.8	5317.3	7089.7	8862.1
16	.54	.07	.61	.15	.69	.22	.77	.30	.84	2.2	4.5	6.8	9.1	1.3
17	.54	.07	.60	.14	.68	.21	.75	.28	.81	2.1	4.2	6.3	8.4	60.5
18	.53	.06	.60	.13	.67	.19	.73	.26	.79	1.9	3.8	5.9	7.8	59.7
19	.53	.06	.59	.12	.65	.18	.71	.24	.77	1.8	3.5	5.4	7.1	8.9
17 20	29.53	59.05	88.58	118.11	147.64	177.16	206.69	236.22	265.74	1771.6	3543.2	5314.9	7086.5	8858.1
21	.53	.05	.57	.10	.63	.14	.67	.20	.72	1.4	2.9	4.4	5.9	7.3
22	.52	.04	.56	.09	.61	.13	.65	.18	.69	1.3	2.6	3.9	5.2	6.5
23	.52	.04	.56	.08	.60	.11	.63	.15	.67	1.1	2.2	3.5	4.6	5.7
24	.52	.03	.55	.07	.58	.10	.61	.13	.64	1.0	1.9	3.0	3.9	4.9
17 25	29.51	59.03	88.54	118.05	147.57	177.08	206.60	236.11	265.62	1770.8	3541.6	5312.5	7083.3	8854.1
26	.51	.02	.53	.04	.56	.06	.58	.09	.60	0.6	1.3	2.1	2.7	3.3
27	.51	.02	.52	.03	.54	.05	.56	.07	.57	0.5	1.0	1.6	2.0	2.5
28	.51	.01	.52	.02	.53	.03	.54	.04	.55	0.3	0.6	1.1	1.4	1.7
29	.50	.01	.51	.01	.51	.02	.52	.02	.52	0.2	0.3	0.6	0.7	0.9
17 30	29.50	59.00	88.50	118.00	147.50	177.00	206.50	236.00	265.50	1770.0	3540.0	5310.1	7080.1	8850.1
31	.50	9.00	.49	7.99	.49	6.98	.48	5.98	.48	69.8	39.7	09.6	79.4	49.3
32	.49	8.99	.48	.98	.47	.97	.46	.96	.45	9.7	9.4	9.1	8.8	8.5
33	.49	.99	.48	.97	.46	.95	.44	.94	.43	9.5	9.0	8.6	8.1	7.6
34	.49	.98	.47	.96	.45	.94	.42	.92	.40	9.4	8.7	8.1	7.5	6.8
17 35	29.48	58.98	88.46	117.94	147.43	176.92	206.41	235.89	265.38	1769.2	3538.4	5307.6	7076.8	8846.0
36	.48	.97	.45	.93	.42	.90	.39	.87	.36	9.0	8.1	7.1	6.2	5.2
37	.48	.97	.44	.92	.41	.89	.37	.85	.33	8.9	7.8	6.6	5.5	4.4
38	.48	.96	.44	.91	.40	.87	.35	.83	.31	8.7	7.4	6.2	4.9	3.6
39	.47	.96	.43	.90	.38	.86	.33	.81	.28	8.6	7.1	5.7	4.2	2.8
17 40	29.47	58.95	88.42	117.89	147.37	176.84	206.31	235.79	265.26	1768.4	3536.8	5305.2	7073.6	8842.0
41	.47	.94	.41	.88	.36	.82	.29	.77	.24	8.2	6.5	4.7	2.9	1.2
42	.47	.94	.40	.87	.34	.81	.27	.75	.21	8.1	6.2	4.2	2.3	40.4
43	.46	.93	.40	.86	.33	.79	.25	.72	.19	7.9	5.8	3.7	1.6	39.5
44	.46	.93	.39	.85	.31	.78	.23	.70	.16	7.8	5.5	3.2	1.0	8.7
17 45	29.46	58.92	88.38	117.83	147.30	176.76	206.22	235.68	265.14	1767.6	3535.2	5302.7	7070.3	8837.9
46	.46	.91	.37	.82	.29	.74	.20	.66	.11	7.4	4.9	2.2	69.6	7.1
47	.46	.91	.36	.81	.27	.73	.18	.64	.09	7.3	4.5	1.7	9.0	6.3
48	.45	.90	.35	.80	.26	.71	.16	.61	.06	7.1	4.2	1.3	8.3	5.4
49	.45	.90	.35	.79	.24	.70	.14	.59	.03	7.0	3.8	0.8	7.7	4.6
17 50	29.45	58.89	88.34	117.78	147.23	176.68	206.12	235.57	265.01	1766.8	3533.5	5300.3	7067.0	8833.8
51	.45	.89	.33	.77	.22	.66	.10	.55	4.99	6.6	3.2	299.8	6.3	3.0
52	.44	.88	.32	.76	.20	.64	.08	.53	.96	6.4	2.9	9.3	5.7	2.2
53	.44	.88	.31	.75	.19	.63	.06	.50	.94	6.3	2.5	8.8	5.0	1.3
54	.44	.87	.31	.74	17	.61	.04	.48	.91	6.1	2.2	8.3	4.4	30.5
17 55	29.43	58.87	88.30	117.72	147.16	176.59	206.03	235.46	264.89	1765.9	3531.9	5297.8	7063.7	8829.7
56	.43	.86	.29	.71	.15	.58	6.01	.44	.87	5.8	1.6	7.3	3.0	8.9
57	.43	.86	.28	.70	.13	.56	5.99	.42	.84	5.6	1.2	6.8	2.4	8.0
58	.43	.85	.27	.69	.12	.54	.97	.39	.82	5.4	0.9	6.3	1.7	7.2
59	.42	.85	.26	.68	.10	.53	.95	.37	.79	5.3	0.5	5.8	1.1	6.3
17 60	29.42	58.84	88.26	117.67	147.09	176.51	205.93	235.35	264.77	1765.1	3530.2	5295.3	7060.4	8825.5

Lat.		Latitude 17° to 18°—Meridional arcs.						Latitude 17°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
17	00	30.740			1844.39						
	1	0	1	30.74	.39	1	1 844.4	0	1	1 774.8	0.1
	2	0	2	61.48	.39	2	3 688.8		2	3 549.6	0.3
	3	0	3	92.22	.39	3	5 533.2		3	5 324.4	0.7
	4	0	4	122.97	.40	4	7 377.6		4	7 099.2	1.2
17	05	30.740	5	153.71	1844.40	5	9 222.0	0	5	8 873.9	1.9
	6	0	6	184.45	.40	6	11 066.4		6	10 648.7	2.7
	7	0	7	215.19	.41	7	12 910.8		7	12 423.5	3.7
	8	0	8	245.93	.41	8	14 755.2		8	14 198.3	4.8
	9	0	9	276.67	.41	9	16 599.6		9	15 973.1	6.1
17	10	30.740	10	307.41	1844.42	10	18 444.0	0	10	17 747.9	7.5
	11	0	1	338.15	.42	11	20 288.5		15	26 621.8	17.0
	12	0	2	368.90	.42	12	22 132.9		20	35 495.8	30.2
	13	0	3	399.64	.43	13	23 977.3		25	44 369.6	47.2
	14	0	4	430.38	.43	14	25 821.7		30	53 243.6	67.9
17	15	30.741	15	461.12	1844.43	15	27 666.2	0	35	62 117.5	92.4
	16	1	6	491.86	.44	16	29 510.6		40	70 991.4	120.7
	17	1	7	522.60	.44	17	31 355.0		45	79 865.3	152.8
	18	1	8	553.34	.44	18	33 199.5		50	88 739.1	188.7
	19	1	9	584.09	.44	19	35 043.9		55	97 613.0	228.3
17	20	30.741	20	614.83	1844.45	20	36 888.4	1	00	106 486.9	271.7
	21	1	1	645.57	.45	21	38 732.8		05	115 360.7	318.8
	22	1	2	676.31	.45	22	40 577.3		10	124 234.5	369.8
	23	1	3	707.05	.46	23	42 421.7		15	133 108.3	424.5
	24	1	4	737.79	.46	24	44 266.2		20	141 982.0	483.0
17	25	30.741	25	768.53	1844.46	25	46 110.7	1	25	150 855.7	545.2
	26	1	6	799.27	.47	26	47 955.1		30	159 729.4	611.3
	27	1	7	830.02	.47	27	49 799.6		35	168 603.1	681.1
	28	1	8	860.76	.47	28	51 644.1		40	177 476.8	754.7
	29	1	9	891.50	.48	29	53 488.6		45	186 350.4	832.1
17	30	30.741	30	922.24	1844.48	30	55 333.0	1	50	195 223.9	913.2
	31	1	1	952.98	.48	31	57 177.5		55	204 097.5	998.1
	32	1	2	983.72	.49	32	59 022.0	2	00	212 971	1 087
	33	1	3	1 014.46	.49	33	60 866.5	3	00	319 450	2 445
	34	2	4	1 045.21	.49	34	62 711.0	4	00	425 920	4 347
17	35	30.742	35	1 075.95	1844.50	35	64 555.5	5	00	532 378	6 792
	36	2	6	1 106.69	.50	36	66 400.0	6	00	638 824	9 779
	37	2	7	1 137.43	.50	37	68 244.5	7	00	745 253	13 310
	38	2	8	1 168.17	.50	38	70 089.0	8	00	851 662	17 386
	39	2	9	1 198.91	.51	39	71 933.5	9	00	958 049	22 004
17	40	30.742	40	1 229.65	1844.51	40	73 778.0	10	00	1 064 411	27 164
	41	2	1	1 260.39	.51	41	75 622.5	11	00	1 170 745	32 867
	42	2	2	1 291.14	.52	42	77 467.0	12	00	1 277 049	39 112
	43	2	3	1 321.88	.52	43	79 311.6	13	00	1 383 320	45 899
	44	2	4	1 352.62	.52	44	81 156.1	14	00	1 489 555	53 229
17	45	30.742	45	1 383.36	1844.53	45	83 000.6	15	00	1 595 750	61 101
	46	2	6	1 414.10	.53	46	84 845.1	16	00	1 701 905	69 515
	47	2	7	1 444.84	.53	47	86 689.7	17	00	1 808 015	78 470
	48	2	8	1 475.58	.54	48	88 534.2	18	00	1 914 078	87 967
	49	2	9	1 506.33	.54	49	90 378.7	19	00	2 020 091	98 005
17	50	30.742	50	1 537.07	1844.54	50	92 223.3	20	00	2 126 051	108 583
	51	2	1	1 567.81	.55	51	94 067.8	21	00	2 231 956	119 702
	52	2	2	1 598.55	.55	52	95 912.3	22	00	2 337 803	131 362
	53	3	3	1 629.29	.55	53	97 756.9	23	00	2 443 589	143 562
	54	3	4	1 660.03	.55	54	99 601.4	24	00	2 549 312	156 301
17	55	30.743	55	1 690.77	1844.56	55	101 446.0	25	00	2 654 968	169 578
	56	3	6	1 721.51	.56	56	103 290.6	26	00	2 760 554	183 395
	57	3	7	1 752.26	.56	57	105 135.1	27	00	2 866 069	197 751
	58	3	8	1 783.00	.57	58	106 979.7	28	00	2 971 510	212 646
	59	3	9	1 813.74	.57	59	108 824.3	29	00	3 076 874	228 079
17	60	30.743	60	1 844.48	1844.57	60	110 668.8	30	00	3 182 157	244 048

Latitude 18° to 19°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
18 00	29.42	58.84	88.26	117.67	147.09	176.51	205.93	235.35	264.77	1765.1	3530.2	5295.3	7060.4	8825.5
1	.42	.83	.25	.66	.08	.49	.91	.33	.75	4.9	29.9	4.8	59.7	4.7
2	.41	.83	.24	.65	.06	.48	.89	.31	.72	4.8	9.5	4.3	9.1	3.9
3	.41	.82	.23	.64	.05	.46	.87	.28	.70	4.6	9.2	3.8	8.4	3.0
4	.41	.82	.22	.63	.03	.44	.85	.26	.67	4.4	8.8	3.3	7.8	2.2
18 05	29.40	58.81	88.21	117.61	147.02	176.43	205.84	235.24	264.65	1764.3	3528.5	5292.8	7057.1	8821.4
6	.40	.80	.21	.60	7.01	.41	.82	.22	.62	4.1	8.2	2.3	6.4	20.6
7	.40	.80	.20	.59	6.99	.39	.80	.20	.60	3.9	7.9	1.8	5.8	19.7
8	.40	.79	.19	.58	.98	.38	.78	.17	.57	3.8	7.5	1.3	5.1	8.9
9	.39	.79	.18	.57	.96	.36	.76	.15	.55	3.6	7.2	0.8	4.5	8.0
18 10	29.39	58.78	88.17	117.56	146.95	176.34	205.74	235.13	264.52	1763.4	3526.9	5290.3	7053.8	8817.2
11	.39	.78	.16	.55	.94	.32	.72	.11	.49	3.2	6.6	89.8	3.1	6.4
12	.38	.77	.15	.54	.92	.31	.70	.08	.47	3.1	6.2	9.3	2.4	5.5
13	.38	.77	.15	.53	.91	.29	.68	.06	.44	2.9	5.9	8.8	1.8	4.7
14	.38	.76	.14	.52	.89	.28	.66	.04	.42	2.8	5.5	8.3	1.1	3.8
18 15	29.37	58.76	88.13	117.50	146.88	176.26	205.64	235.01	264.39	1762.6	3525.2	5287.8	7050.4	8813.0
16	.37	.75	.12	.49	.87	.24	.62	4.99	.36	2.4	4.9	7.3	49.7	2.2
17	.37	.75	.11	.48	.85	.23	.60	.97	.34	2.3	4.5	6.8	9.1	1.3
18	.37	.74	.11	.47	.84	.21	.58	.95	.31	2.1	4.2	6.3	8.4	10.5
19	.36	.74	.10	.46	.82	.20	.56	.92	.29	2.0	3.8	5.8	7.8	09.6
18 20	29.36	58.73	88.09	117.45	146.81	176.18	205.54	234.90	264.26	1761.8	3523.5	5285.3	7047.1	8808.8
21	.36	.72	.08	.44	.80	.16	.52	.88	.24	1.6	3.2	4.8	6.4	8.0
22	.35	.72	.07	.43	.78	.14	.50	.86	.21	1.4	2.8	4.3	5.7	7.1
23	.35	.71	.06	.42	,77	.13	.48	.83	.19	1.3	2.5	3.7	5.1	6.3
24	.35	.71	.05	.41	.75	.11	.46	.81	.16	1.1	2.1	3.2	4.4	5.4
18 25	29.34	58.70	88.05	117.39	146.74	176.09	205.44	234.79	264.14	1760.9	3521.8	5282.7	7043.7	8804.6
26	.34	.69	.04	.38	.73	.07	.42	.77	.11	0.7	1.5	2.2	3.0	3.7
27	.34	.69	.03	.37	.71	.06	.40	.75	.09	0.6	1.1	1.7	2.3	2.9
28	.34	.68	.02	.36	.70	.04	.38	.72	.06	0.4	0.8	1.2	1.7	2.0
29	.33	.68	.01	.35	.68	.03	.36	.70	.04	0.3	0.4	0.7	1.0	1.2
18 30	29.33	58.67	88.00	117.34	146.67	176.01	205.34	234.68	264.01	1760.1	3520.1	5280.2	7040.3	8800.3
31	.33	.66	7.99	.33	.66	5.99	.32	.66	3.98	59.9	19.8	79.7	39.6	799.5
32	.33	.66	.99	.32	.64	.97	.30	.63	.96	9.7	9.4	9.2	8.9	8.6
33	.32	.65	.98	.30	.63	.96	.28	.61	.93	9.6	9.1	8.6	8.2	7.7
34	.32	.65	.97	.29	.61	.94	.26	.59	.91	9.4	8.7	8.1	7.5	6.9
18 35	29.32	58.64	87.96	117.28	146.60	175.92	205.24	234.56	263.88	1759.2	3518.4	5277.6	7036.8	8796.1
36	.32	.63	.95	.27	.59	.90	.22	.54	.85	9.0	8.1	7.1	6.1	5.2
37	.32	.63	.94	.26	.57	.89	.20	.52	.83	8.9	7.7	6.6	5.4	4.4
38	.31	.62	.94	.24	.56	.87	.18	.50	.80	8.7	7.4	6.1	4.8	3.5
39	.31	.62	.93	.23	.54	.86	.16	.47	.78	8.6	7.0	5.6	4.1	2.7
18 40	29.31	58.61	87.92	117.22	146.53	175.84	205.14	234.45	263.75	1758.4	3516.7	5275.1	7033.4	8791.8
41	.31	.60	.91	.21	.52	.82	.12	.43	.72	8.2	6.4	4.6	2.7	0.9
42	.30	.60	.90	.20	.50	.80	.10	.40	.70	8.0	6.0	4.1	2.0	90.1
43	.30	.59	.89	.19	.49	.79	.08	.38	.67	7.9	5.7	3.5	1.4	89.2
44	.30	.59	.88	.18	.47	.77	.06	.36	.65	7.7	5.3	3.0	0.7	8.4
18 45	29.29	58.58	87.87	117.16	146.46	175.75	205.04	234.33	263.62	1757.5	3515.0	5272.5	7030.0	8787.5
46	.29	.57	.87	.15	.45	.73	.02	.31	.59	7.3	4.7	2.0	29.3	6.6
47	.29	.57	.86	.14	.43	.71	5.00	.29	.57	7.1	4.3	1.5	8.6	5.8
48	.29	.56	.85	.13	.42	.70	4.98	.27	.54	7.0	4.0	0.9	7.9	4.9
49	.28	.56	.84	.12	.40	.68	.96	.24	.52	6.8	3.6	70.4	7.2	4.1
18 50	29.28	58.55	87.83	117.11	146.39	175.66	204.94	234.22	263.49	1756.6	3513.3	5269.9	7026.5	8783.2
51	.28	.55	.82	.10	.38	.64	.92	.20	.46	6.4	2.9	9.4	5.8	2.3
52	.27	.54	.81	.09	.36	.63	.90	.17	.44	6.3	2.6	8.9	5.1	1.4
53	.27	.54	.81	.07	.35	.61	.88	.15	.41	6.1	2.2	8.3	4.4	80.6
54	.27	.53	.80	.06	.33	.59	.86	.13	.39	5.9	1.9	7.8	3.7	79.7
18 55	29.26	58.53	87.79	117.05	146.32	175.58	204.84	234.10	263.37	1755.8	3511.5	5267.3	7023.0	8778.8
56	.26	.52	.78	.04	.30	.56	.82	.08	.35	5.6	1.2	6.8	2.3	7.9
57	.26	.52	.77	.03	.29	.54	.80	.06	.31	5.4	0.8	6.3	1.6	7.1
58	.26	.51	.76	.01	.27	.52	.78	.04	.28	5.2	0.5	5.7	1.0	6.2
59	.25	.51	.75	7.00	.26	.51	.76	4.01	.26	5.1	10.1	5.2	20.3	5.4
18 60	29.25	58.50	87.74	116.99	146.24	175.49	204.74	233.99	263.23	1754.9	3509.8	5264.7	7019.0	8774.5

Lat.	Latitude 18° to 19°—Meridional arcs.						Latitude 18°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
18 00	30.743			1844.57					
1	3	1	30.74	.58	1	1 844.6	0 1	1 765.1	0.1
2	3	2	61.49	.58	2	3 689.2	2	3 530.2	0.3
3	3	3	92.23	.58	3	5 533.7	3	5 295.3	0.7
4	3	4	122.98	.59	4	7 378.3	4	7 060.4	1.3
18 05	30.743	5	153.72	1844.59	5	9 222.9	0 5	8 825.5	2.0
6	3	6	184.47	.59	6	11 067.5	6	10 590.6	2.9
7	3	7	215.21	.60	7	12 912.1	7	12 355.7	3.9
8	3	8	245.96	.60	8	14 756.7	8	14 120.8	5.1
9	3	9	276.70	.60	9	16 601.3	9	15 886.0	6.4
18 10	30.743	10	307.45	1844.61	10	18 445.9	0 10	17 651.1	7.9
11	3	1	338.19	.61	1	20 290.5	15	26 476.6	17.8
12	4	2	368.93	.61	2	22 135.1	20	35 302.1	31.7
13	4	3	399.68	.62	3	23 979.8	25	44 127.7	49.6
14	4	4	430.42	.62	4	25 824.4	30	52 953.2	71.4
18 15	30.744	15	461.17	1844.62	15	27 669.0	0 35	61 778.7	97.2
16	4	6	491.91	.62	6	29 513.6	40	70 604.2	126.9
17	4	7	522.66	.63	7	31 358.2	45	79 429.7	160.6
18	4	8	553.40	.63	8	33 202.9	50	88 255.1	198.3
19	4	9	584.15	.63	9	35 047.5	55	97 080.6	240.0
18 20	30.744	20	614.89	1844.64	20	36 892.2	1 00	105 906.0	285.6
21	4	1	645.64	.64	1	38 736.8	05	114 731.4	335.2
22	4	2	676.38	.64	2	40 581.4	10	123 556.8	388.7
23	4	3	707.12	.65	3	42 426.1	15	132 382.1	446.2
24	4	4	737.87	.65	4	44 270.7	20	141 207.5	507.7
18 25	30.744	25	768.61	1844.65	25	46 115.4	1 25	150 032.8	573.2
26	4	6	799.36	.66	6	47 960.0	30	158 858.0	642.6
27	4	7	830.10	.66	7	49 804.7	35	167 683.3	716.0
28	4	8	860.85	.66	8	51 649.4	40	176 508.5	793.3
29	4	9	891.59	.67	9	53 494.0	45	185 333.6	874.6
18 30	30.744	30	922.33	1844.67	30	55 338.7	1 50	194 158.8	959.9
31	5	1	953.08	.67	1	57 183.4	55	202 983.8	1 049.2
32	5	2	983.83	.68	2	59 028.1	2 00	211 809	1 142
33	5	3	1 014.57	.68	3	60 872.7	3 00	317 706	2 570
34	5	4	1 045.31	.68	4	62 717.4	4 00	423 593	4 569
18 35	30.745	35	1 076.06	1844.69	35	64 562.1	5 00	529 468	7 139
36	5	6	1 106.80	.69	6	66 406.8	6 00	635 328	10 280
37	5	7	1 137.55	.69	7	68 251.5	7 00	741 169	13 992
38	5	8	1 168.29	.70	8	70 096.2	8 00	846 989	18 275
39	5	9	1 199.04	.70	9	71 940.9	9 00	952 784	23 129
18 40	30.745	40	1 229.78	1844.70	40	73 785.6	10 00	1 058 552	28 553
41	5	1	1 260.53	.71	1	75 630.3	11 00	1 164 289	34 547
42	5	2	1 291.27	.71	2	77 475.0	12 00	1 269 991	41 112
43	5	3	1 322.02	.71	3	79 319.7	13 00	1 375 657	48 246
44	5	4	1 352.76	.72	4	81 164.4	14 00	1 481 283	55 950
18 45	30.745	45	1 383.50	1844.72	45	83 009.2	15 00	1 586 865	64 224
46	5	6	1 414.25	.72	6	84 853.9	16 00	1 692 402	73 067
47	5	7	1 444.99	.73	7	86 698.6	17 00	1 797 890	82 479
48	5	8	1 475.74	.73	8	88 543.3	18 00	1 903 324	92 461
49	6	9	1 506.48	.73	9	90 388.0	19 00	2 008 704	103 011
18 50	30.746	50	1 537.23	1844.74	50	92 232.8	20 00	2 114 025	114 128
51	6	1	1 567.97	.74	1	94 077.5	21 00	2 219 285	125 813
52	6	2	1 598.72	.74	2	95 922.3	22 00	2 324 480	138 066
53	6	3	1 629.46	.75	3	97 767.0	23 00	2 429 607	150 887
54	6	4	1 660.21	.75	4	99 611.8	24 00	2 534 664	164 274
18 55	30.746	55	1 690.95	1844.75	55	101 456.5	25 00	2 639 647	178 227
56	6	6	1 721.69	.76	6	103 301.3	26 09	2 744 554	192 746
57	6	7	1 752.44	.76	7	105 146.1	27 00	2 849 381	207 831
58	6	8	1 783.18	.76	8	106 990.8	28 00	2 954 124	223 482
59	6	9	1 813.93	.77	9	108 835.6	29 00	3 058 782	239 697
18 60	30.746	60	1 844.67	1844.77	60	110 680.4	30 00	3 163 350	256 476

Latitude 19° to 20°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
19 00	29.25	58.50	87.74	116.99	146.24	175.49	204.74	233.99	263.23	1754.9	3509.8	5264.7	7019.6	8774.5
1	.25	.49	.74	.98	.23	.47	.72	.97	.20	4.7	9.4	4.2	8.9	3.6
2	.24	.49	.73	.97	.21	.45	.70	.94	.18	4.5	9.1	3.6	8.2	2.7
3	.24	.48	.72	.96	.20	.44	.68	.92	.15	4.4	8.7	3.1	7.5	1.9
4	.24	.48	.71	.95	.18	.42	.66	.89	.13	4.2	8.4	2.5	6.8	1.0
19 05	29.23	58.47	87.70	116.93	146.17	175.40	204.63	233.87	263.10	1754.0	3508.0	5262.0	7016.1	8770.1
6	.23	.46	.69	.92	.16	.38	.61	.85	.07	3.8	7.7	1.5	5.4	69.2
7	.23	.46	.68	.91	.14	.36	.59	.82	.05	3.6	7.3	1.0	4.7	8.3
8	.23	.45	.68	.90	.13	.35	.57	.80	.02	3.5	7.0	60.4	4.0	7.5
9	.22	.45	.67	.89	.11	.33	.55	.77	63.00	3.3	6.6	59.9	3.3	6.6
19 10	29.22	58.44	87.66	116.88	146.10	175.31	204.53	233.75	262.97	1753.1	3506.3	5259.4	7012.6	8765.7
11	.22	.43	.65	.87	.09	.29	.51	.73	.94	2.9	5.9	8.9	1.9	4.8
12	.21	.43	.64	.86	.07	.28	.49	.70	.92	2.8	5.6	8.4	1.2	3.9
13	.21	.42	.63	.84	.06	.26	.47	.68	.89	2.6	5.2	7.8	10.4	3.1
14	.21	.42	.62	.83	.04	.24	.45	.66	.87	2.4	4.9	7.3	09.7	2.2
19 15	29.20	58.41	87.61	116.82	146.03	175.23	204.43	233.63	262.84	1752.3	3504.5	5256.8	7009.0	8761.3
16	.20	.40	.60	.81	.01	.21	.41	.61	.81	2.1	4.1	6.3	8.3	60.4
17	.20	.40	.60	.80	6.00	.19	.39	.59	.79	1.9	3.8	5.7	7.6	59.5
18	.20	.39	.59	.78	5.98	.17	.37	.57	.76	1.7	3.4	5.2	6.9	8.7
19	.19	.39	.58	.77	.97	.16	.35	.54	.74	1.6	3.1	4.6	6.2	7.8
19 20	29.19	58.38	87.57	116.76	145.95	175.14	204.33	233.52	262.71	1751.4	3502.7	5254.1	7005.5	8756.9
21	.19	.37	.56	.75	.94	.12	.31	.50	.68	1.2	2.4	3.6	4.8	6.0
22	.18	.37	.55	.74	.92	.10	.29	.47	.66	1.0	2.0	3.0	4.1	5.1
23	.18	.36	.54	.72	.91	.09	.27	.45	.63	0.9	1.7	2.5	3.3	4.2
24	.18	.36	.53	.71	.89	.07	.25	.42	.60	0.7	1.3	1.9	2.6	3.3
19 25	29.17	58.35	87.52	116.70	145.88	175.05	204.22	233.40	262.57	1750.5	3501.0	5251.4	7001.9	8752.4
26	.17	.34	.52	.69	.86	.03	.20	.38	.55	0.3	0.6	0.9	1.2	1.5
27	.17	.34	.51	.68	.85	.01	.18	.35	.52	0.1	500.3	50.4	7000.5	50.6
28	.17	.33	.50	.66	.83	5.00	.16	.33	.49	50.0	499.9	49.8	6999.7	49.7
29	.16	.33	.49	.65	.82	4.98	.14	.30	.47	49.8	9.6	9.3	9.0	8.8
19 30	29.16	58.32	87.48	116.64	145.80	174.96	204.12	233.28	262.44	1749.6	3499.2	5248.8	6998.3	8747.9
31	.16	.31	.47	.63	.79	.94	.10	.26	.41	9.4	8.8	8.3	7.6	7.0
32	.15	.31	.46	.62	.77	.92	.08	.23	.39	9.2	8.5	7.7	6.9	6.1
33	.15	.30	.45	.60	.76	.91	.06	.21	.36	9.1	8.1	7.2	6.1	5.2
34	.15	.30	.44	.59	.74	.89	.04	.18	.33	8.9	7.8	6.6	5.4	4.3
19 35	29.14	58.29	87.43	116.58	145.73	174.87	204.01	233.16	262.30	1748.7	3497.4	5246.1	6994.7	8743.4
36	.14	.28	.43	.57	.71	.85	3.99	.14	.28	8.5	7.0	5.6	4.0	2.5
37	.14	.28	.42	.56	.70	.83	.97	.11	.25	8.3	6.7	5.0	3.3	1.6
38	.14	.27	.41	.54	.68	.82	.95	.09	.22	8.2	6.3	4.5	2.6	40.7
39	.13	.27	.40	.53	.67	.80	.93	.06	.20	8.0	6.0	3.9	1.9	39.8
19 40	29.13	58.26	87.39	116.52	145.65	174.78	203.91	233.04	262.17	1747.8	3495.6	5243.4	6991.2	8738.9
41	.13	.25	.38	.51	.64	.76	.89	3.02	.14	7.6	5.2	2.8	90.5	8.0
42	.12	.25	.37	.50	.62	.74	.87	2.99	.12	7.4	4.9	2.3	89.7	7.1
43	.12	.24	.36	.48	.61	.73	.85	.97	.09	7.3	4.5	1.7	9.0	6.2
44	.12	.24	.35	.47	.59	.71	.83	.94	.06	7.1	4.2	1.2	8.2	5.3
19 45	29.11	58.23	87.34	116.46	145.58	174.69	203.80	232.92	262.03	1746.9	3493.8	5240.6	6987.5	8734.4
46	.11	.22	.34	.45	.56	.67	.78	.90	2.01	6.7	3.4	40.1	6.8	3.5
47	.11	.22	.33	.44	.55	.65	.76	.87	1.98	6.5	3.0	39.5	6.1	2.6
48	.11	.21	.32	.42	.53	.64	.74	.85	.95	6.4	2.7	9.0	5.3	1.7
49	.10	.21	.31	.41	.52	.62	.72	.82	.93	6.2	2.3	8.4	4.6	30.8
19 50	29.10	58.20	87.30	116.40	145.50	174.60	203.70	232.80	261.90	1746.0	3491.9	5237.9	6983.9	8729.9
51	.10	.19	.29	.39	.49	.58	.68	.78	.87	5.8	1.5	7.4	3.2	9.0
52	.09	.19	.28	.38	.47	.56	.66	.75	.84	5.6	1.2	6.8	2.4	8.1
53	.09	.18	.27	.36	.46	.54	.63	.73	.82	5.4	0.8	6.3	1.7	7.1
54	.09	.18	.26	.35	.44	.52	.61	.70	.79	5.2	0.5	5.7	0.9	6.2
19 55	29.08	58.17	87.25	116.34	145.43	174.51	203.59	232.68	261.76	1745.1	3490.1	5235.2	6980.2	8725.3
56	.08	.16	.24	.33	.41	.49	.57	.65	.73	4.9	89.7	4.6	79.5	4.4
57	.08	.16	.24	.32	.40	.47	.55	.63	.70	4.7	9.4	4.1	8.8	3.5
58	.08	.15	.23	.30	.38	.45	.52	.60	.68	4.5	9.0	3.5	8.0	2.5
59	.07	.15	.22	.29	.37	.43	.50	.58	.65	4.3	8.7	3.0	7.3	1.6
19 60	29.07	58.14	87.21	116.28	145.35	174.41	203.48	232.55	261.62	1744.1	3488.3	5232.4	6976.6	8720.7

Lat.	Latitude 19° to 20°—Meridional arcs.						Latitude 19°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
19 00	30.746			1844.77					
1	6	1	30.75	.77	1	1 844.8	0 1	1 754.9	0.1
2	6	2	61.50	.78	2	3 689.5	2	3 509.8	0.3
3	6	3	92.24	.78	3	5 534.3	3	5 264.7	0.7
4	6	4	122.99	.78	4	7 379.1	4	7 019.6	1.3
19 05	30.746	5	153.74	1844.79	5	9 223.9	0 5	8 774.5	2.1
6	6	6	184.49	.79	6	11 068.7	6	10 529.3	3.0
7	7	7	215.24	.79	7	12 913.5	7	12 284.2	4.1
8	7	8	245.98	.80	8	14 758.3	8	14 039.1	5.3
9	7	9	276.73	.80	9	16 603.1	9	15 794.0	6.7
19 10	30.747	10	307.48	1844.80	10	18 447.9	0 10	17 548.9	8.3
11	7	1	338.23	.81	1	20 292.7	15	26 323.4	18.7
12	7	2	368.97	.81	2	22 137.5	20	35 097.8	33.2
13	7	3	399.72	.81	3	23 982.3	25	43 872.3	51.9
14	7	4	430.47	.82	4	25 827.1	30	52 646.7	74.8
19 15	30.747	15	461.22	1844.82	15	27 672.0	0 35	61 421.1	101.8
16	7	6	491.97	.82	6	29 516.8	40	70 195.5	133.0
17	7	7	522.71	.83	7	31 361.6	45	78 969.9	168.3
18	7	8	553.46	.83	8	33 206.4	50	87 744.3	207.7
19	7	9	584.21	.83	9	35 051.3	55	96 518.7	251.4
19 20	30.747	20	614.96	1844.84	20	36 896.1	1 00	105 293.0	299.2
21	7	1	645.71	.84	1	38 741.0	05	114 067.3	351.1
22	7	2	676.45	.84	2	40 585.8	10	122 841.6	407.2
23	7	3	707.20	.85	3	42 430.6	15	131 615.9	467.4
24	8	4	737.95	.85	4	44 275.5	20	140 390.1	531.8
19 25	30.748	25	768.70	1844.85	25	46 120.4	1 25	149 164.3	600.4
26	8	6	799.45	.86	6	47 965.2	30	157 938.5	673.1
27	8	7	830.19	.86	7	49 810.1	35	166 712.6	750.0
28	8	8	860.94	.86	8	51 654.9	40	175 486.7	831.0
29	8	9	891.69	.87	9	53 499.8	45	184 260.7	916.1
19 30	30.748	30	922.44	1844.87	30	55 344.7	1 50	193 034.7	1 005.5
31	8	1	953.18	.87	1	57 189.6	55	201 808.7	1 099.0
32	8	2	983.93	.88	2	59 034.4	2 00	210 583	1 197
33	8	3	1 014.68	.88	3	60 879.3	3 00	315 866	2 692
34	8	4	1 045.43	.89	4	62 724.2	4 00	421 138	4 786
19 35	30.748	35	1 076.18	1844.89	35	64 569.1	5 00	526 397	7 478
36	8	6	1 106.92	.89	6	66 414.0	6 00	631 639	10 768
37	8	7	1 137.67	.90	7	68 258.9	7 00	736 861	14 656
38	8	8	1 168.42	.90	8	70 103.8	8 00	842 059	19 142
39	8	9	1 199.17	.90	9	71 948.7	9 00	947 230	24 226
19 40	30.748	40	1 229.92	1844.91	40	73 793.6	10 00	1 052 369	29 907
41	8	1	1 260.66	.91	1	75 638.5	11 00	1 157 475	36 186
42	9	2	1 291.41	.91	2	77 483.4	12 00	1 262 544	43 061
43	9	3	1 322.16	.92	3	79 328.3	13 00	1 367 572	50 534
44	9	4	1 352.91	.92	4	81 173.3	14 00	1 472 556	58 603
19 45	30.749	45	1 383.66	1844.92	45	83 018.2	15 00	1 577 492	67 268
46	9	6	1 414.40	.93	6	84 863.1	16 00	1 682 377	76 530
47	9	7	1 445.15	.93	7	86 708.0	17 00	1 787 208	86 388
48	9	8	1 475.90	.93	8	88 553.0	18 00	1 891 981	96 841
49	9	9	1 506.65	.94	9	90 397.9	19 00	1 996 693	107 889
19 50	30.749	50	1 537.39	1844.94	50	92 242.8	20 00	2 101 342	119 532
51	9	1	1 568.14	.94	1	94 087.8	21 00	2 205 922	131 770
52	9	2	1 598.89	.95	2	95 932.7	22 00	2 310 430	144 601
53	9	3	1 629.64	.95	3	97 777.7	23 00	2 414 864	158 026
54	9	4	1 660.39	.95	4	99 622.6	24 00	2 519 221	172 044
19 55	30.749	55	1 691.13	1844.96	55	101 467.6	25 00	2 623 495	186 655
56	9	6	1 721.88	.96	6	103 312.6	26 00	2 727 685	201 859
57	9	7	1 752.63	.97	7	105 157.5	27 00	2 831 787	217 654
58	49	8	1 783.38	.97	8	107 002.5	28 00	2 935 798	234 040
59	50	9	1 814.13	.97	9	108 847.5	29 00	3 039 714	251 017
19 60	30.750	60	1 844.87	1844.98	60	110 692.4	30 00	3 143 531	268 585

Latitude 20° to 21°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
20 00	29.07	58.14	87.21	116.28	145.35	174.41	203.48	232.55	261.62	1744.1	3488.3	5232.4	6976.6	8720.7
1	.07	.13	.20	.27	.33	.39	.46	.53	.59	3.9	7.9	1.9	5.9	19.8
2	.06	.13	.19	.25	.32	.37	.44	.50	.57	3.7	7.5	1.3	5.1	8.9
3	.06	.12	.18	.24	.30	.36	.42	.48	.54	3.6	7.2	0.8	4.4	7.9
4	.06	.12	.17	.23	.29	.34	.40	.45	.51	3.4	6.8	30.2	3.6	7.0
20 05	29.05	58.11	87.16	116.21	145.27	174.32	203.37	232.43	261.48	1743.2	3486.4	5229.7	6972.9	8716.1
6	.05	.10	.15	.20	.25	.30	.35	.41	.46	3.0	6.0	9.1	2.2	5.2
7	.05	.10	.14	.19	.24	.28	.33	.38	.43	2.8	5.7	8.6	1.4	4.3
8	.05	.09	.13	.18	.22	.27	.31	.36	.40	2.7	5.3	8.0	70.7	3.3
9	.04	.09	.12	.16	.21	.25	.29	.33	.38	2.5	5.0	7.5	69.9	2.4
20 10	29.04	58.08	87.12	116.15	145.19	174.23	203.27	232.31	261.35	1742.3	3484.6	5226.9	6969.2	8711.5
11	.04	.07	.11	.14	.18	.21	.25	.29	.32	2.1	4.2	6.3	8.5	10.6
12	.03	.07	.10	.13	.16	.19	.23	.26	.29	1.9	3.8	5.8	7.7	09.7
13	.03	.06	.09	.11	.15	.17	.20	.24	.27	1.7	3.5	5.2	7.0	8.7
14	.03	.05	.08	.10	.13	.16	.18	.21	.24	1.6	3.1	4.7	6.2	7.8
20 15	29.02	58.04	87.07	116.09	145.12	174.14	203.16	232.19	261.21	1741.4	3482.7	5224.1	6965.5	8706.9
16	.02	.04	.06	.08	.10	.12	.14	.16	.18	1.2	2.3	3.5	4.8	6.0
17	.02	.03	.05	.07	.09	.10	.12	.14	.15	1.0	2.0	3.0	4.0	5.0
18	.02	.02	.04	.05	.07	.08	.09	.11	.13	0.8	1.7	2.4	3.3	4.1
19	.01	.02	.03	.04	.06	.06	.07	.09	.10	0.6	1.3	1.9	2.5	3.1
20 20	29.01	58.01	87.02	116.03	145.04	174.04	203.05	232.06	261.07	1740.4	3480.9	5221.3	6961.8	8702.2
21	.01	.00	.01	.02	.02	.02	.03	.04	.04	0.2	0.5	0.7	1.0	1.3
22	.00	8.00	7.00	6.00	5.01	4.00	3.01	2.01	1.01	40.0	80.1	20.2	60.3	700.3
23	.00	7.99	6.99	5.99	4.99	3.99	2.98	1.99	0.99	39.9	79.8	19.6	59.5	699.4
24	9.00	.99	.98	.98	.98	.97	.96	.96	.96	9.7	9.4	9.1	8.8	8.4
20 25	28.99	57.98	86.97	115.96	144.96	173.95	202.94	231.94	260.93	1739.5	3479.0	5218.5	6958.0	8697.5
26	.99	.97	.97	.95	.94	.93	.92	.91	.90	9.3	8.6	7.9	7.3	6.6
27	.99	.97	.96	.94	.93	.91	.90	.89	.87	9.1	8.2	7.4	6.5	5.7
28	.99	.96	.95	.93	.91	.90	.87	.86	.85	9.0	7.9	6.8	5.8	4.7
29	.98	.96	.94	.91	.90	.88	.85	.84	.82	8.8	7.5	6.3	5.0	3.8
20 30	28.98	57.95	86.93	115.90	144.88	173.86	202.83	231.81	260.79	1738.6	3477.1	5215.7	6954.3	8692.9
31	.98	.94	.92	.89	.86	.84	.81	.79	.76	8.4	6.7	5.1	3.5	1.9
32	.97	.94	.91	.88	.85	.82	.79	.76	.73	8.2	6.4	4.6	2.8	1.0
33	.97	.93	.90	.86	.83	.80	.76	.74	.70	8.0	6.0	4.0	2.0	90.0
34	.96	.93	.89	.85	.82	.78	.74	.71	.67	7.8	5.7	3.5	1.3	89.1
20 35	28.96	57.92	86.88	115.84	144.80	173.76	202.72	231.69	260.65	1737.6	3475.3	5212.9	6950.5	8688.1
36	.96	.91	.87	.83	.78	.74	.70	.66	.62	7.4	4.9	2.3	49.7	7.2
37	.95	.91	.86	.82	.77	.72	.68	.64	.59	7.2	4.5	1.8	9.0	6.2
38	.95	.90	.85	.80	.75	.71	.65	.61	.56	7.1	4.2	1.2	8.2	5.3
39	.94	.90	.84	.79	.74	.69	.63	.59	.53	6.9	3.8	0.7	7.5	4.3
20 40	28.94	57.89	86.83	115.78	144.72	173.67	202.61	231.56	260.50	1736.7	3473.4	5210.1	6946.7	8683.4
41	.94	.88	.82	.77	.71	.65	.59	.53	.47	6.5	3.0	09.5	5.9	2.5
42	.93	.88	.81	.75	.69	.63	.57	.51	.44	6.3	2.6	8.9	5.2	1.5
43	.93	.87	.81	.74	.68	.61	.54	.48	.42	6.1	2.3	8.4	4.4	80.6
44	.93	.87	.80	.73	.66	.59	.52	.46	.39	5.9	1.9	7.8	3.7	79.6
20 45	28.92	57.86	86.79	115.71	144.65	173.57	202.50	231.43	260.36	1735.7	3471.5	5207.2	6942.9	8678.7
46	.92	.85	.78	.70	.63	.55	.48	.40	.33	5.5	1.1	6.6	2.1	7.7
47	.92	.85	.77	.69	.62	.54	.46	.38	.30	5.4	0.7	6.1	1.4	6.8
48	.92	.84	.76	.68	.60	.52	.43	.35	.28	5.2	0.4	5.5	40.6	5.8
49	.91	.84	.75	.66	.59	.50	.41	.33	.25	5.0	70.0	5.0	39.9	4.9
20 50	28.91	57.83	86.74	115.65	144.57	173.48	202.39	231.30	260.22	1734.8	3469.6	5204.4	6939.1	8673.9
51	.91	.82	.73	.64	.55	.46	.37	.28	.19	4.6	9.2	3.8	8.3	2.9
52	.90	.82	.72	.62	.54	.44	.35	.25	.16	4.4	8.8	3.2	7.6	2.0
53	.90	.81	.71	.61	.52	.42	.32	.23	.13	4.2	8.5	2.7	6.8	1.0
54	.90	.80	.70	.60	.51	.40	.30	.20	.10	4.0	8.1	2.1	6.1	70.1
20 55	28.89	57.79	86.69	115.58	144.49	173.38	202.28	231.18	260.07	1733.8	3467.7	5201.5	6935.3	8669.1
56	.89	.79	.68	.57	.47	.36	.26	.15	.05	3.6	7.3	0.9	4.5	8.1
57	.89	.78	.67	.56	.46	.34	.24	.13	60.02	3.4	6.9	200.3	3.8	7.2
58	.89	.77	.66	.55	.44	.33	.21	.10	59.99	3.3	6.5	199.8	3.1	6.2
59	.88	.77	.65	.53	.43	.31	.19	.08	.96	3.1	6.1	9.2	2.3	5.3
20 60	28.88	57.76	86.64	115.52	144.41	173.29	202.17	231.05	259.93	1732.9	3465.7	5198.6	6931.5	8664.3

Lat.		Latitude 20° to 21°—Meridional arcs.						Latitude 20°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value o 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
20	00	30.750			1844.98						
	1	0	1	30.75	.98	1	1 845.0	0	1	1 744.1	0.1
	2	0	2	61.50	.98	2	3 690.0		2	3 488.3	0.3
	3	0	3	92.25	.99	3	5 534.9		3	5 232.4	0.8
	4	0	4	123.01	.99	4	7 379.9		4	6 976.6	1.4
20	05	30.750	5	153.76	1844.99	5	9 224.9	0	5	8 720.7	2.2
	6	0	6	184.51	5.00	6	11 069.9		6	10 464.9	3.1
	7	0	7	215.26	.00	7	12 914.9		7	12 209.0	4.3
	8	0	8	246.01	.00	8	14 759.9		8	13 953.1	5.6
	9	0	9	276.76	.01	9	16 604.9		9	15 697.3	7.0
20	10	30.750	10	307.51	1845.01	10	18 450.0	0	10	17 441.4	8.7
	11	0	1	338.27	.01	1	20 295.0		15	26 162.1	19.5
	12	0	2	369.02	.02	2	22 140.0		20	34 882.8	34.7
	13	0	3	399.77	.02	3	23 985.0		25	43 603.5	54.2
	14	0	4	430.52	.02	4	25 830.0		30	52 324.2	78.1
20	15	30.750	15	461.27	1845.03	15	27 675.1	0	35	61 044.9	106.3
	16	1	6	492.02	.03	9	29 520.1		40	69 765.6	138.8
	17	1	7	522.77	.04	7	31 365.1		45	78 486.2	175.7
	18	1	8	553.53	.04	8	33 210.2		50	87 206.9	216.9
	19	1	9	584.28	.04	9	35 055.2		55	95 927.5	262.5
20	20	30.751	20	615.03	1845.05	20	36 900.3	1	00	104 648.0	312.3
	21	1	1	645.78	.05	1	38 745.3		05	113 368.6	366.6
	22	1	2	676.53	.05	2	40 590.4		10	122 089.1	425.1
	23	1	3	707.28	.06	3	42 435.4		15	130 809.6	488.0
	24	1	4	738.03	.06	4	44 280.5		20	139 530.1	555.3
20	25	30.751	25	768.79	1845.06	25	46 125.5	1	25	148 250.5	626.8
	26	1	6	799.54	.07	6	47 970.6		30	156 970.9	702.8
	27	1	7	830.29	.07	7	49 815.7		35	165 691.3	783.0
	28	1	8	861.04	.07	8	51 660.8		40	174 411.6	867.6
	29	1	9	891.79	.08	9	53 505.8		45	183 131.8	956.5
20	30	30.751	30	922.54	1845.08	30	55 350.9	1	50	191 852.1	1 049.8
	31	1	1	953.29	.09	1	57 196.0		55	200 572.3	1 147.4
	32	1	2	984.04	.09	2	59 041.1	2	00	209 292	1 249
	33	2	3	1 014.80	.09	3	60 886.2	3	00	313 929	2 811
	34	2	4	1 045.55	.10	4	62 731.3	4	00	418 555	4 997
20	35	30.752	35	1 076.30	1845.10	35	64 576.4	5	00	523 166	7 808
	36	2	6	1 107.05	.10	6	66 421.5	6	00	627 758	11 243
	37	2	7	1 137.80	.11	7	68 266.6	7	00	732 328	15 302
	38	2	8	1 168.55	.11	8	70 111.7	8	00	836 871	19 986
	39	2	9	1 199.30	.11	9	71 956.8	9	00	941 385	25 294
20	40	30.752	40	1 230.06	1845.12	40	73 801.9	10	00	1 045 865	31 225
	41	2	1	1 260.81	.12	1	75 647.1	11	00	1 150 308	37 780
	42	2	2	1 291.56	.12	2	77 492.2	12	00	1 254 710	44 958
	43	2	3	1 322.31	.13	3	79 337.3	13	00	1 359 067	52 760
	44	2	4	1 353.06	.13	4	81 182.4	14	00	1 463 376	61 184
20	45	30.752	45	1 383.81	1845.14	45	83 027.6	15	00	1 567 633	70 230
	46	2	6	1 414.56	.14	6	84 872.7	16	00	1 671 834	79 899
	47	2	7	1 445.32	.14	7	86 717.9	17	00	1 775 975	90 190
	48	2	8	1 476.07	.15	8	88 563.0	18	00	1 880 054	101 102
	49	2	9	1 506.82	.15	9	90 408.2	19	00	1 984 064	112 635
20	50	30.753	50	1 537.57	1845.15	50	92 253.3	20	00	2 088 005	124 789
	51	3	1	1 568.32	.16	1	94 098.5	21	00	2 191 871	137 563
	52	3	2	1 599.07	.16	2	95 943.6	22	00	2 295 659	150 957
	53	3	3	1 629.82	.16	3	97 788.8	23	00	2 399 364	164 970
	54	3	4	1 660.58	.17	4	99 634.0	24	00	2 502 985	179 602
20	55	30.753	55	1 691.33	1845.17	55	101 479.1	25	00	2 606 516	194 853
	56	3	6	1 722.08	.18	6	103 324.3	26	00	2 709 955	210 721
	57	3	7	1 752.83	.18	7	105 169.5	27	00	2 813 297	227 206
	58	3	8	1 783.58	.18	8	107 014.7	28	00	2 916 538	244 308
	59	3	9	1 814.33	.19	9	108 859.9	29	00	3 019 676	262 026
20	60	30.753	60	1 845.08	1845.19	60	110 705.1	30	00	3 122 706	280 359

Latitude 21° to 22°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
21 00	28.88	57.76	86.64	115.52	144.41	173.29	202.17	231.05	259.93	1732.9	3465.7	5198.6	6931.5	8664.3
1	.88	.75	.63	.51	.39	.27	.15	.02	.90	2.7	5.3	8.0	30.7	3.3
2	.87	.75	.62	.50	.38	.25	.12	1.00	.87	2.5	4.9	7.4	29.9	2.4
3	.87	.74	.61	.48	.36	.23	.10	0.97	.84	2.3	4.6	6.9	9.2	1.4
4	.87	.74	.60	.47	.34	.21	.08	.95	.81	2.1	4.2	6.3	8.4	60.5
21 05	28.86	57.73	86.59	115.46	144.32	173.19	202.05	230.92	259.79	1731.9	3463.8	5195.7	6927.6	8659.5
6	.86	.72	.59	.45	.31	.17	.03	.89	.76	1.7	3.4	5.1	6.8	8.5
7	.86	.72	.58	.44	.29	.15	2.01	.87	.73	1.5	3.0	4.5	6.0	7.6
8	.86	.71	.57	.42	.27	.13	1.99	.84	.70	1.3	2.7	4.0	5.3	6.6
9	.85	.71	.56	.41	.26	.11	.96	.82	.67	1.1	2.3	3.4	4.5	5.7
21 10	28.85	57.70	86.55	115.40	144.24	173.09	201.94	230.79	259.64	1730.9	3461.9	5192.8	6923.7	8654.7
11	.85	.69	.54	.39	.22	.07	.92	.76	.61	0.7	1.5	2.2	2.9	3.7
12	.84	.69	.53	.37	.21	.05	.90	.74	.58	0.5	1.1	1.6	2.1	2.7
13	.84	.68	.52	.36	.19	.04	.87	.71	.55	0.4	0.7	1.1	1.4	1.8
14	.84	.67	.51	.35	.18	.02	.85	.69	.52	0.2	60.3	90.5	20.6	50.8
21 15	28.83	57.66	86.50	115.34	144.16	173.00	201.83	230.66	259.50	1730.0	3459.8	5189.9	6919.8	8649.8
16	.83	.66	.49	.32	.14	2.98	.81	.63	.47	29.8	9.4	9.3	9.0	8.8
17	.83	.65	.48	.31	.13	.96	.79	.61	.44	9.6	9.1	8.7	8.3	7.9
18	.83	.64	.47	.30	.11	.94	.76	.58	.41	9.4	8.7	8.2	7.5	6.9
19	.82	.64	.46	.28	.10	.92	.74	.56	.38	9.2	8.4	7.6	6.8	6.0
21 20	28.82	57.63	86.45	115.27	144.08	172.90	201.72	230.53	259.35	1729.0	3458.0	5187.0	6916.0	8645.0
21	.82	.62	.44	.26	.06	.88	.70	.50	.32	8.8	7.6	6.4	5.2	4.0
22	.81	.62	.43	.24	.05	.86	.67	.48	.29	8.6	7.2	5.8	4.4	3.0
23	.81	.61	.42	.23	.03	.84	.65	.45	.26	8.4	6.8	5.2	3.6	2.1
24	.80	.61	.41	.22	.02	.82	.63	.43	.23	8.2	6.4	4.6	2.8	1.1
21 25	28.80	57.60	86.40	115.21	144.00	172.80	201.60	230.40	259.21	1728.0	3456.0	5184.0	6912.0	8640.1
26	.80	.59	.39	.19	3.98	.78	.58	.37	.18	7.8	5.6	3.4	1.2	39.1
27	.79	.59	.38	.18	.97	.76	.56	.35	.15	7.6	5.2	2.8	10.4	8.1
28	.79	.58	.37	.17	.95	.74	.54	.32	.12	7.4	4.9	2.3	09.7	7.2
29	.78	.58	.36	.15	.94	.72	.51	.30	.09	7.2	4.5	1.7	8.9	6.2
21 30	28.78	57.57	86.35	115.14	143.92	172.70	201.49	230.27	259.06	1727.0	3454.1	5181.1	6908.1	8635.2
31	.78	.56	.34	.13	.90	.68	.47	.24	.03	6.8	3.7	80.5	7.3	4.2
32	.77	.56	.33	.11	.89	.66	.44	.22	9.00	6.6	3.3	79.9	6.5	3.2
33	.77	.55	.32	.10	.87	.64	.42	.19	8.97	6.4	2.9	9.3	5.8	2.2
34	.77	.54	.31	.08	.85	.62	.40	.17	.94	6.2	2.5	8.7	5.0	1.2
21 35	28.76	57.53	86.30	115.07	143.83	172.60	201.37	230.14	258.91	1726.0	3452.1	5178.1	6904.2	8630.2
36	.76	.53	.29	.06	.82	.58	.35	.11	.88	5.8	1.7	7.5	3.4	29.2
37	.76	.52	.28	.04	.80	.56	.33	.09	.85	5.6	1.3	6.9	2.6	8.2
38	.76	.51	.27	.03	.78	.55	.31	.06	.82	5.5	0.9	6.4	1.8	7.3
39	.75	.51	.26	.01	.77	.53	.28	.04	.79	5.3	0.5	5.8	1.0	6.3
21 40	28.75	57.50	86.25	115.00	143.75	172.51	201.26	230.01	258.76	1725.1	3450.1	5175.2	6900.2	8625.3
41	.75	.49	.24	4.99	.73	.49	.24	29.98	.73	4.9	49.7	4.6	899.4	4.3
42	.74	.49	.23	.97	.71	.47	.21	.96	.70	4.7	9.3	4.0	8.6	3.3
43	.74	.48	.22	.96	.69	.45	.19	.93	.67	4.5	8.9	3.4	7.8	2.3
44	.74	.48	.21	.95	.67	.43	.16	.90	.64	4.3	8.5	2.8	7.0	1.3
21 45	28.73	57.47	86.20	114.94	143.66	172.41	201.14	229.87	258.61	1724.1	3448.1	5172.2	6896.2	8620.3
46	.73	.46	.19	.92	.65	.39	.12	.85	.58	3.9	7.7	1.6	5.4	19.3
47	.73	.46	.18	.91	.64	.37	.09	.83	.55	3.7	7.3	1.0	4.6	8.3
48	.73	.45	.17	.90	.62	.35	.07	.79	.52	3.5	6.9	70.4	3.9	7.3
49	.72	.45	.16	.88	.61	.33	.04	.77	.49	3.3	6.5	69.8	3.1	6.3
21 50	28.72	57.44	86.15	114.87	143.59	172.31	201.02	229.74	258.46	1723.1	3446.1	5169.2	6892.3	8615.3
51	.72	.43	.14	.86	.57	.29	1.00	.71	.43	2.9	5.7	8.6	1.5	4.3
52	.71	.43	.13	.84	.56	.27	0.97	.69	.40	2.7	5.3	8.0	90.7	3.3
53	.71	.42	.12	.83	.54	.25	.95	.66	.37	2.5	4.9	7.4	89.9	2.3
54	.70	.41	.11	.82	.52	.23	.93	.64	.34	2.3	4.5	6.8	9.1	1.3
21 55	28.70	57.40	86.10	114.80	143.50	172.21	200.90	229.61	258.31	1722.1	3444.1	5166.2	6888.3	8610.3
56	.70	.40	.09	.79	.49	.19	.88	.58	.28	1.9	3.7	5.6	7.5	09.3
57	.69	.39	.08	.78	.47	.17	.86	.56	.25	1.7	3.3	5.0	6.7	8.3
58	.69	.38	.07	.77	.45	.15	.84	.53	.22	1.5	2.9	4.4	5.9	7.3
59	.68	.38	.06	.75	.44	.13	.81	.51	.19	1.3	2.5	3.8	5.1	6.3
21 60	28.68	57.37	86.05	114.74	143.42	172.11	200.79	229.48	258.16	1721.1	3442.1	5163.2	6884.3	8605.3

Lat.		Latitude 21° to 22°—Meridional arcs.						Latitude 21°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
21	00	30.753			1845.19						
	1	3	1	30.76	.20	1	1 845.2	0	1	1 732.9	0.1
	2	3	2	61.51	.20	2	3 690.4		2	3 465.7	0.4
	3	3	3	92.27	.20	3	5 535.6		3	5 198.6	0.8
	4	3	4	123.02	.21	4	7 380.8		4	6 931.5	1.4
21	05	30.753	5	153.78	1845.21	5	9 226.0	0	5	8 664.3	2.2
	6	4	6	184.53	.21	6	11 071.2		6	10 397.2	3.2
	7	4	7	215.29	.22	7	12 916.4		7	12 130.0	4.4
	8	4	8	246.04	.22	8	14 761.7		8	13 862.9	5.8
	9	4	9	276.80	.23	9	16 606.9		9	15 595.8	7.3
21	10	30.754	10	307.55	1845.23	10	18 452.1	0	10	17 328.6	9.0
	11	4	1	338.31	.23	1	20 297.3		15	25 993.0	20.3
	12	4	2	369.06	.24	2	22 142.6		20	34 657.3	36.1
	13	4	3	399.82	.24	3	23 987.8		25	43 321.6	56.4
	14	4	4	430.57	.24	4	25 833.1		30	51 985.9	81.3
21	15	30.754	15	461.33	1845.25	15	27 678.3	0	35	60 650.2	110.7
	16	4	6	492.08	.25	6	29 523.6		40	69 314.5	144.5
	17	4	7	522.84	.25	7	31 368.8		45	77 978.7	182.9
	18	4	8	553.59	.26	8	33 214.1		50	86 643.0	225.8
	19	4	9	584.35	.26	9	35 059.3		55	95 307.2	273.2
21	20	30.754	20	615.10	1845.27	20	36 904.6	1	00	103 971.3	325.2
	21	4	1	645.86	.27	1	38 749.9		05	112 635.5	381.6
	22	5	2	676.61	.27	2	40 595.1		10	121 299.6	442.5
	23	5	3	707.37	.28	3	42 440.4		15	129 963.7	508.0
	24	5	4	738.12	.28	4	44 285.7		20	138 627.7	578.0
21	25	30.755	25	768.88	1845.28	25	46 131.0	1	25	147 291.8	652.5
	26	5	6	799.63	.29	6	47 976.3		30	155 955.7	731.6
	27	5	7	830.39	.29	7	49 821.5		35	164 619.7	815.1
	28	5	8	861.14	.30	8	51 666.8		40	173 283.6	903.2
	29	5	9	891.90	.30	9	53 512.1		45	181 947.4	995.8
21	30	30.755	30	922.65	1845.30	30	55 357.4	1	50	190 611.2	1 092.9
	31	5	1	953.41	.31	1	57 202.7		55	199 274.9	1 194.5
	32	5	2	984.16	.31	2	59 048.0	2	00	207 939	1 301
	33	5	3	1 014.92	.31	3	60 893.4	3	00	311 898	2 926
	34	5	4	1 045.67	.32	4	62 738.7	4	00	415 845	5 202
21	35	30.755	35	1 076.43	1845.32	35	64 584.0	5	00	519 775	8 128
	36	5	6	1 107.18	.33	6	66 429.3	6	00	623 686	11 704
	37	5	7	1 137.94	.33	7	68 274.6	7	00	727 572	15 930
	38	6	8	1 168.69	.33	8	70 120.0	8	00	831 429	20 806
	39	6	9	1 199.45	.34	9	71 965.3	9	00	935 254	26 331
21	40	30.756	40	1 230.20	1845.34	40	73 810.6	10	00	1 039 042	32 505
	41	6	1	1 260.96	.34	1	75 656.0	11	00	1 142 790	39 328
	42	6	2	1 291.71	.35	2	77 501.3	12	00	1 246 493	46 801
	43	6	3	1 322.47	.35	3	79 346.7	13	00	1 350 147	54 922
	44	6	4	1 353.22	.36	4	81 192.0	14	00	1 453 749	63 690
21	45	30.756	45	1 383.98	1845.36	45	83 037.4	15	00	1 557 294	73 107
	46	6	6	1 414.73	.36	6	84 882.8	16	00	1 660 777	83 171
	47	6	7	1 445.49	.37	7	86 728.1	17	00	1 764 195	93 882
	48	6	8	1 476.24	.37	8	88 573.5	18	00	1 867 545	105 240
	49	6	9	1 507.00	.37	9	90 418.9	19	00	1 970 822	117 244
21	50	30.756	50	1 537.75	1845.38	50	92 264.2	20	00	2 074 021	129 893
	51	6	1	1 568.51	.38	1	94 109.6	21	00	2 177 139	143 188
	52	6	2	1 599.26	.39	2	95 955.0	22	00	2 280 173	157 128
	53	6	3	1 630.02	.39	3	97 800.4	23	00	2 383 117	171 712
	54	7	4	1 660.77	.39	4	99 645.8	24	00	2 485 967	186 939
21	55	30.757	55	1 691.53	1845.40	55	101 491.2	25	00	2 588 720	202 809
	56	7	6	1 722.28	.40	6	103 336.6	26	00	2 691 373	219 322
	57	7	7	1 753.04	.40	7	105 182.0	27	00	2 793 920	236 476
	58	7	8	1 783.79	.41	8	107 027.4	28	00	2 896 358	254 272
	59	7	9	1 814.55	.41	9	108 872.8	29	00	2 998 682	272 708
21	60	30.757	60	1 845.30	1845.42	60	110 718.2	30	00	3 100 889	291 784

Latitude 22° to 23°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
22 00	28.68	57.37	86.05	114.74	143.42	172.11	200.79	229.48	258.16	1721.1	3442.1	5163.2	6884.3	8605.3
1	.68	.36	.04	.73	.40	.09	.77	.45	.13	0.9	1.7	2.6	3.5	4.3
2	.67	.36	.03	.71	.39	.07	.74	.43	.10	0.7	1.3	2.0	2.7	3.3
3	.67	.35	.02	.70	.37	.05	.72	.40	.07	0.5	0.9	1.4	1.8	2.3
4	.67	.34	.01	.68	.35	.03	.69	.37	.04	0.3	0.5	0.8	1.0	1.3
22 05	28.66	57.33	86.00	114.67	143.33	172.01	200.67	229.35	258.01	1720.1	3440.1	5160.2	6880.2	8600.3
6	.66	.33	5.99	.66	.32	1.99	.65	.32	7.98	19.9	39.7	59.6	79.4	599.3
7	.66	.32	.98	.64	.30	.97	.62	.29	.95	9.7	9.3	9.0	8.6	8.3
8	.66	.31	.97	.63	.28	.94	.60	.26	.92	9.4	8.9	8.3	7.8	7.2
9	.65	.31	.96	.61	.27	.92	.57	.24	.89	9.2	8.5	7.7	7.0	6.2
22 10	28.65	57.30	85.95	114.60	143.25	171.90	200.55	229.21	257.86	1719.0	3438.1	5157.1	6876.2	8595.2
11	.65	.29	.94	.59	.23	.88	.53	.18	.83	8.8	7.7	6.5	5.4	4.2
12	.64	.29	.93	.57	.22	.86	.50	.16	.80	8.6	7.3	5.9	4.6	3.2
13	.64	.28	.92	.56	.20	.84	.48	.13	.77	8.4	6.9	5.3	3.7	2.2
14	.64	.27	.91	.55	.18	.82	.46	.10	.74	8.2	6.5	4.7	2.9	1.2
22 15	28.63	57.26	85.90	114.54	143.16	171.80	200.43	229.07	257.70	1718.0	3436.1	5154.1	6872.1	8590.1
16	.63	.26	.89	.52	.15	.78	.41	.05	.67	7.8	5.7	3.5	1.3	89.1
17	.63	.25	.88	.51	.13	.76	.39	9.02	.64	7.6	5.3	2.9	70.5	8.1
18	.63	.24	.87	.50	.11	.74	.37	8.99	.61	7.4	4.8	2.2	69.7	7.1
19	.62	.24	.86	.48	.10	.72	.34	.97	.58	7.2	4.4	1.6	8.9	6.1
22 20	28.62	57.23	85.85	114.47	143.08	171.70	200.32	228.94	257.55	1717.0	3434.0	5151.0	6868.1	8585.1
21	.62	.22	.84	.46	.06	.68	.30	.91	.52	6.8	3.6	50.4	7.3	4.0
22	.61	.22	.83	.44	.05	.66	.27	.88	.49	6.6	3.2	49.8	6.5	3.0
23	.61	.21	.82	.43	.03	.64	.25	.86	.46	6.4	2.8	9.2	5.6	2.0
24	.60	.21	.81	.41	.01	.62	.22	.83	.43	6.2	2.4	8.6	4.8	81.0
22 25	28.60	57.20	85.80	114.40	143.00	171.60	200.20	228.80	257.40	1716.0	3432.0	5148.0	6864.0	8579.9
26	.60	.19	.79	.39	2.98	.58	.18	.77	.37	5.8	1.6	7.4	3.2	8.9
27	.59	.19	.78	.37	.96	.56	.15	.74	.34	5.6	1.2	6.8	2.4	7.9
28	.59	.18	.77	.36	.94	.54	.13	.72	.31	5.4	0.7	6.1	1.5	6.9
29	.58	.18	.76	.34	.93	.52	.10	.69	.28	5.2	30.3	5.5	60.7	5.9
22 30	28.58	57.17	85.75	114.33	142.91	171.50	200.08	228.66	257.25	1715.0	3429.9	5144.9	6859.9	8574.8
31	.58	.16	.74	.32	.89	.48	.06	.63	.22	4.8	9.5	4.3	9.1	3.8
32	.57	.16	.73	.30	.88	.46	.03	.60	.19	4.6	9.1	3.7	8.3	2.7
33	.57	.15	.72	.29	.86	.43	200.01	.58	.16	4.3	8.7	3.0	7.4	1.7
34	.57	.14	.71	.27	.84	.41	199.98	.55	.13	4.1	8.3	2.4	6.6	70.7
22 35	28.56	57.13	85.70	114.26	142.82	171.39	199.96	228.52	257.09	1713.9	3427.9	5141.8	6855.8	8569.7
36	.56	.13	.69	.25	.81	.37	.94	.49	.06	3.7	7.5	1.2	5.0	8.6
37	.56	.12	.68	.23	.79	.35	.91	.46	.03	3.5	7.1	40.6	4.1	7.6
38	.56	.11	.67	.22	.77	.33	89	.44	7.00	3.3	6.6	39.9	3.3	6.6
39	.55	.11	.66	.20	.76	.31	.86	.41	6.97	3.1	6.2	9.3	2.4	5.6
22 40	28.55	57.10	85.65	114.19	142.74	171.29	199.84	228.38	256.94	1712.9	3425.8	5138.7	6851.6	8564.5
41	.55	.09	.64	.18	.72	.27	.82	.35	.91	2.7	5.4	8.1	0.8	3.5
42	.54	.09	.62	.16	.71	.25	.79	.33	.88	2.5	5.0	7.5	50.0	2.4
43	.54	.08	.61	.15	.69	.23	.77	.30	.84	2.3	4.5	6.8	49.1	1.4
44	.53	.07	.60	.14	.67	.21	.74	.27	.81	2.1	4.1	6.2	8.3	60.4
22 45	28.53	57.06	85.59	114.12	142.66	171.19	199.72	228.25	256.78	1711.9	3423.7	5135.6	6847.5	8559.3
46	.53	.06	.58	.11	.64	.17	.70	.22	.75	1.7	3.3	5.0	6.7	8.3
47	.52	.05	.57	.10	.62	.15	.67	.19	.72	1.5	2.9	4.4	5.8	7.3
48	.52	.04	.56	.09	.60	.12	.65	.16	.68	1.2	2.5	3.7	5.0	6.2
49	.51	.04	.55	.07	.59	.10	.62	.14	.65	1.0	2.1	3.1	4.1	5.2
22 50	28.51	57.03	85.54	114.06	142.57	171.08	199.60	228.11	256.62	1710.8	3421.7	5132.5	6843.3	8554.1
51	.51	.02	.53	.05	.55	.06	.58	.08	.59	0.6	1.3	1.9	2.5	3.1
52	.50	.02	.52	.03	.53	.04	.55	.05	.56	0.4	0.9	1.2	1.6	2.0
53	.50	.01	.51	.02	.52	.02	.53	.03	.53	0.2	0.4	30.6	40.8	1.0
54	.50	57.00	.50	4.00	.50	1.00	.50	8.00	.50	10.0	20.0	29.9	39.9	50.0
22 55	28.49	56.99	85.49	113.99	142.48	170.98	199.48	227.97	256.46	1709.8	3419.6	5129.3	6839.1	8548.9
56	.49	.99	.48	.98	.46	.96	.45	.94	.43	9.6	9.2	8.7	8.3	7.9
57	.49	.98	.47	.96	.44	.94	.43	.91	.40	9.4	8.8	8.1	7.4	6.8
58	.49	.97	.46	.95	.43	.92	.40	.89	.37	9.2	8.3	7.4	6.5	5.8
59	.48	.97	.45	.93	.41	.89	.38	.86	.34	8.9	7.9	6.8	5.7	4.7
22 60	28.48	56.96	85.44	113.92	142.39	170.87	199.35	227.83	256.31	1708.7	3417.5	5126.2	6834.9	8543.7

Lat.	Latitude 22° to 23°—Meridional arcs.						Latitude 22°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
22 00	30.757			1845.42					
1	7	1	30.76	.42	1	1 845.4	0 1	1 721.1	0.1
2	7	2	61.52	.42	2	3 690.8	2	3 442.2	0.4
3	7	3	92.28	.43	3	5 536.3	3	5 163.2	0.8
4	7	4	123.04	.43	4	7 381.7	4	6 884.3	1.5
22 05	30.757	5	153.79	1845.44	5	9 227.1	0 5	8 605.4	2.3
6	7	6	184.55	.44	6	11 072.6	6	10 326.5	3.4
7	7	7	215.31	.44	7	12 918.0	7	12 047.5	4.6
8	7	8	246.07	.45	8	14 763.4	8	13 768.6	6.0
9	7	9	276.83	.45	9	16 608.9	9	15 489.7	7.6
22 10	30.758	10	307.59	1845.45	10	18 454.3	0 10	17 210.7	9.4
11	8	1	338.35	.46	1	20 299.8	15	25 816.0	21.1
12	8	2	369.11	.46	2	22 145.3	20	34 421.3	37.5
13	8	3	399.86	.47	3	23 990.7	25	43 026.6	58.6
14	8	4	430.62	.47	4	25 836.2	30	51 631.8	84.4
22 15	30.758	15	461.38	1845.47	15	27 681.7	0 35	60 237.1	114.9
16	8	6	492.14	.48	6	29 527.1	40	68 842.3	150.0
17	8	7	522.90	.48	7	31 372.6	45	77 447.6	189.9
18	8	8	553.66	.48	8	33 218.1	50	86 052.8	234.4
19	8	9	584.42	.49	9	35 063.6	55	94 657.9	283.7
22 20	30.758	20	615.18	1845.49	20	36 909.1	1 00	103 263.1	337.6
21	8	1	645.94	.50	1	38 754.6	05	111 868.2	396.2
22	8	2	676.69	.50	2	40 600.1	10	120 473.3	459.5
23	8	3	707.45	.50	3	42 445.6	15	129 078.3	527.5
24	8	4	738.21	.51	4	44 291.1	20	137 683.3	600.1
22 25	30.759	25	768.97	1845.51	25	46 136.6	1 25	146 288.3	677.5
26	9	6	799.73	.52	6	47 982.1	30	154 893.2	759.5
27	9	7	830.49	.52	7	49 827.6	35	163 498.1	846.3
28	9	8	861.25	.52	8	51 673.1	40	172 102.9	937.7
29	9	9	892.01	.53	9	53 518.7	45	180 707.7	1 033.8
22 30	30.759	30	922.77	1845.53	30	55 364.2	1 50	189 312.4	1 134.6
31	9	1	953.52	.53	1	57 209.7	55	197 917.1	1 240.1
32	9	2	984.28	.54	2	59 055.3	2 00	206 522	1 350
33	9	3	1 015.04	.54	3	60 900.8	3 00	309 772	3 037
34	9	4	1 045.80	.55	4	62 746.3	4 00	413 008	5 400
22 35	30.759	35	1 076.56	1845.55	35	64 591.9	5 00	516 227	8 438
36	9	6	1 107.32	.55	6	66 437.4	6 00	619 424	12 151
37	9	7	1 138.08	.56	7	68 283.0	7 00	722 595	16 538
38	9	8	1 168.84	.56	8	70 128.6	8 00	825 734	21 600
39	9	9	1 199.59	.57	9	71 974.1	9 00	928 838	27 336
22 40	30.759	40	1 230.35	1845.57	40	73 819.7	10 00	1 031 903	33 746
41	60	1	1 261.11	.57	1	75 665.3	11 00	1 134 923	40 829
42	0	2	1 291.87	.58	2	77 510.8	12 00	1 237 895	48 586
43	0	3	1 322.63	.58	3	79 356.4	13 00	1 340 814	57 016
44	0	4	1 353.39	.58	4	81 202.0	14 00	1 443 675	66 119
22 45	30.760	45	1 384.15	1845.59	45	83 047.6	15 00	1 546 475	75 894
46	0	6	1 414.91	.59	6	84 893.2	16 00	1 649 209	86 341
47	0	7	1 445.67	.60	7	86 738.8	17 00	1 751 873	97 459
48	0	8	1 476.42	.60	8	88 584.4	18 00	1 854 461	109 248
49	0	9	1 507.18	.60	9	90 430.0	19 00	1 956 970	121 708
22 50	30.760	50	1 537.94	1845.61	50	92 275.6	20 00	2 059 396	134 838
51	0	1	1 568.70	.61	1	94 121.2	21 00	2 161 733	148 637
52	0	2	1 599.46	.62	2	95 966.8	22 00	2 263 978	163 105
53	0	3	1 630.22	.62	3	97 812.4	23 00	2 366 126	178 241
54	0	4	1 660.98	.62	4	99 658.0	24 00	2 468 174	194 045
22 55	30.760	55	1 691.74	1845.63	55	101 503.7	25 00	2 570 116	210 515
56	1	6	1 722.50	.63	6	103 349.3	26 00	2 671 947	227 652
57	1	7	1 753.25	.64	7	105 194.9	27 00	2 773 664	245 454
58	1	8	1 784.01	.64	8	107 040.6	28 00	2 875 264	263 921
59	1	9	1 814.77	.64	9	108 886.2	29 00	2 976 740	283 051
22 60	30.761	60	1 845.53	1845.65	60	110 731.8	30 00	3 078 089	302 845

Latitude 23° to 24°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
23 00	28.48	56.96	85.44	113.92	142.39	170.87	199.35	227.83	256.31	1708.7	3417.5	5126.2	6834.9	8543.7
1	.48	.95	.43	.91	.37	.85	.33	.80	.28	8.5	7.1	5.6	4.1	2.6
2	.47	.95	.42	.89	.36	.83	.30	.77	.25	8.3	6.7	5.0	3.2	1.6
3	.47	.94	.41	.88	.34	.81	.28	.75	.22	8.1	6.2	4.3	2.4	40.5
4	.46	.93	.40	.86	.32	.79	.25	.72	.19	7.9	5.8	3.7	1.5	39.5
23 05	28.46	56.92	85.38	113.85	142.31	170.77	199.23	227.69	256.15	1707.7	3415.4	5123.1	6830.7	8538.4
6	.46	.92	.37	.84	.29	.75	.21	.66	.12	7.5	5.0	2.5	29.9	7.4
7	.45	.91	.36	.82	.27	.73	.18	.63	.09	7.3	4.6	1.8	9.0	6.3
8	.45	.90	.35	.81	.25	.71	.16	.61	.06	7.1	4.1	1.2	8.2	5.3
9	.44	.90	.34	.79	.24	.68	.13	.58	.03	6.8	3.7	20.5	7.3	4.2
23 10	28.44	56.89	85.33	113.78	142.22	170.66	199.11	227.55	256.00	1706.6	3413.3	5119.9	6826.5	8533.2
11	.44	.88	.32	.77	.20	.64	.09	.52	5.97	6.4	2.9	9.3	5.7	2.1
12	.43	.88	.31	.75	.18	.62	.06	.49	.94	6.2	2.5	8.6	4.8	1.1
13	.43	.87	.30	.74	.17	.60	.04	.47	.90	6.0	2.0	8.0	4.0	30.0
14	.43	.86	.29	.72	.15	.58	9.01	.44	.87	5.8	1.6	7.3	3.1	28.9
23 15	28.42	56.85	85.28	113.71	142.13	170.56	198.99	227.41	255.84	1705.6	3411.2	5116.7	6822.3	8527.9
16	.42	.85	.27	.69	.11	.54	.96	.38	.81	5.4	0.8	6.1	1.5	6.8
17	.42	.84	.26	.68	.09	.52	.94	.35	.78	5.2	10.3	5.4	20.6	5.8
18	.42	.83	.25	.66	.08	.49	.91	.33	.74	4.9	09.9	4.8	19.8	4.7
19	.41	.83	.24	.65	.06	.47	.89	.30	.71	4.7	9.4	4.1	8.9	3.6
23 20	28.41	56.82	85.23	113.63	142.04	170.45	198.86	227.27	255.68	1704.5	3409.0	5113.5	6818.1	8522.6
21	.41	.81	.22	.62	.02	.43	.84	.24	.65	4.3	8.6	2.9	7.2	1.5
22	.40	.81	.20	.60	2.01	.41	.81	.21	.62	4.1	8.2	2.2	6.4	20.4
23	.40	.80	.19	.59	1.99	.39	.79	.18	.58	3.9	7.7	1.6	5.5	19.4
24	.39	.79	.18	.57	.97	.37	.76	.15	.55	3.7	7.3	0.9	4.7	8.3
23 25	28.39	56.78	85.17	113.56	141.96	170.34	198.74	227.13	255.52	1703.4	3406.9	5110.3	6813.8	8517.2
26	.39	.78	.16	.55	.94	.32	.71	.10	.49	3.2	6.5	09.7	2.9	6.2
27	.38	.77	.15	.53	.92	.30	.69	.07	.46	3.0	6.1	9.0	2.1	5.1
28	.38	.76	.14	.52	.90	.28	.66	.04	.42	2.8	5.6	8.4	1.2	4.0
29	.37	.76	.13	.50	.89	.26	.64	7.01	.39	2.6	5.2	7.7	10.4	3.0
23 30	28.37	56.75	85.12	113.49	141.87	170.24	198.61	226.98	255.36	1702.4	3404.8	5107.1	6809.5	8511.9
31	.37	.74	.11	.48	.85	.22	.59	.95	.33	2.2	4.4	6.5	8.6	10.8
32	.36	.73	.10	.46	.83	.20	.56	.92	.29	2.0	3.9	5.8	7.8	09.8
33	.36	.73	.09	.45	.82	.17	.54	.90	.26	1.7	3.5	5.2	6.9	8.7
34	.36	.72	.08	.43	.80	.15	.51	.87	.23	1.5	3.0	4.5	6.1	7.6
23 35	28.35	56.71	85.06	113.42	141.78	170.13	198.49	226.84	255.19	1701.3	3402.6	5103.9	6805.2	8506.5
36	.35	.70	.05	.41	.76	.11	.46	.81	.16	1.1	2.2	3.3	4.3	5.5
37	.35	.69	.04	.39	.74	.09	.44	.78	.13	0.9	1.8	2.6	3.5	4.4
38	.35	.69	.03	.38	.73	.06	.41	.76	.10	0.6	1.3	2.0	2.6	3.3
39	.34	.68	.02	.36	.71	.04	.39	.73	.06	0.4	0.9	1.3	1.8	2.2
23 40	28.34	56.67	85.01	113.35	141.69	170.02	198.36	226.70	255.03	1700.2	3400.5	5100.7	6800.9	8501.2
41	.34	.66	5.00	.34	.67	70.00	.34	.67	5.00	700.0	400.1	100.0	800.0	500.1
42	.33	.66	4.99	.32	.65	69.98	.31	.64	4.97	699.8	399.6	5099.4	799.2	499.0
43	.33	.65	.98	.31	.64	.96	.29	.61	.93	9.6	9.2	8.7	8.3	7.9
44	.32	.64	.97	.29	.62	.94	.26	.58	.90	9.4	8.7	8.1	7.5	6.8
23 45	28.32	56.63	84.96	113.28	141.60	169.92	198.24	226.56	254.87	1699.2	3398.3	5097.4	6796.6	8495.8
46	.32	.63	.95	.26	.58	.89	.21	.53	.84	8.9	7.9	6.8	5.7	4.7
47	.31	.62	.94	.25	.56	.87	.19	.50	.81	8.7	7.4	6.1	4.9	3.6
48	.31	.61	.93	.23	.55	.85	.16	.47	.77	8.5	7.0	5.5	4.0	2.5
49	.30	.61	.91	.22	.53	.83	.14	.44	.74	8.3	6.5	4.8	3.2	1.4
23 50	28.30	56.60	84.90	113.20	141.51	169.81	198.11	226.41	254.71	1698.1	3396.1	5094.2	6792.3	8490.4
51	.30	.59	.89	.19	.49	.79	.08	.38	.68	7.9	5.7	3.5	1.4	89.3
52	.29	.59	.88	.17	.47	.77	.06	.35	.64	7.7	5.3	2.9	90.5	8.2
53	.29	.58	.87	.16	.45	.74	.03	.32	.61	7.4	4.8	2.2	89.7	7.1
54	.28	.57	.86	.14	.43	.72	8.01	.29	.58	7.2	4.4	1.6	8.8	6.0
23 55	28.28	56.56	84.85	113.13	141.42	169.70	197.98	226.27	254.54	1697.0	3394.0	5090.9	6787.9	8484.9
56	.28	.56	.84	.12	.40	.68	.95	.24	.51	6.8	3.6	90.3	7.0	3.8
57	.27	.55	.83	.10	.38	.66	.93	.21	.48	6.6	3.1	89.6	6.2	2.7
58	.27	.54	.82	.09	.36	.63	.90	.18	.45	6.3	2.7	9.0	5.3	1.6
59	.26	.54	.80	.07	.34	.61	.88	.15	.41	6.1	2.2	8.3	4.5	80.5
23 60	28.26	56.53	84.79	113.06	141.32	169.59	197.85	226.12	254.38	1695.9	3391.8	5087.7	6783.6	8479.5

Lat.	Latitude 23° to 24°—Meridional arcs.						Latitude 23°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
23 00	30.761			1845.65					
1	1	1	30.76	.65	1	1 845.6	0 1	1 708.7	0.1
2	1	2	61.53	.66	2	3 691.3	2	3 417.5	0.4
3	1	3	92.29	.66	3	5 537.0	3	5 126.2	0.9
4	1	4	123.05	.66	4	7 382.6	4	6 835.0	1.6
23 05	30.761	5	153.81	1845.67	5	9 228.3	0 5	8 543.7	2.4
6	1	6	184.58	.67	6	11 073.9	6	10 252.4	3.5
7	1	7	215.34	.67	7	12 919.6	7	11 961.2	4.8
8	1	8	246.10	.68	8	14 765.3	8	13 669.9	6.2
9	1	9	276.86	.68	9	16 611.0	9	15 378.6	7.9
23 10	30.761	10	307.63	1845.69	10	18 456.7	0 10	17 087.4	9.7
11	2	1	338.39	.69	1	20 302.3	15	25 631.0	21.8
12	2	2	369.15	.69	2	22 148.0	20	34 174.7	38.8
13	2	3	399.92	.70	3	23 993.7	25	42 718.4	60.7
14	2	4	430.68	.70	4	25 839.4	30	51 262.0	87.4
23 15	30.762	15	461.44	1845.71	15	27 685.1	0 35	59 805.7	118.9
16	2	6	492.20	.71	6	29 530.8	40	68 349.3	155.4
17	2	7	522.97	.71	7	31 376.6	45	76 892.8	196.6
18	2	8	553.73	.72	8	33 222.3	50	85 436.4	242.8
19	2	9	584.49	.72	9	35 068.0	55	93 979.9	293.7
23 20	30.762	20	615.26	1845.73	20	36 913.7	1 00	102 523.4	349.6
21	2	1	646.02	.73	1	38 759.4	05	111 066.9	410.3
22	2	2	676.78	.73	2	40 605.2	10	119 610.3	475.8
23	2	3	707.54	.74	3	42 450.9	15	128 153.7	546.2
24	2	4	738.31	.74	4	44 296.7	20	136 697.1	621.5
23 25	30.762	25	769.07	1845.75	25	46 142.4	1 25	145 240.4	701.6
26	2	6	799.83	.75	6	47 988.1	30	153 783.6	786.6
27	3	7	830.59	.75	7	49 833.9	35	162 326.8	876.4
28	3	8	861.36	.76	8	51 679.7	40	170 870.0	971.1
29	3	9	892.12	.76	9	53 525.4	45	179 413.1	1 070.6
23 30	30.763	30	922.88	1845.77	30	55 371.2	1 50	187 956.1	1 175.0
31	3	1	953.65	.77	1	57 216.9	55	196 499.1	1 284.2
32	3	2	984.41	.77	2	59 062.7	2 00	205 042	1 398
33	3	3	1 015.17	.78	3	60 908.5	3 00	307 551	3 146
34	3	4	1 045.93	.78	4	62 754.3	4 00	410 046	5 593
23 35	30.763	35	1 076.70	1845.79	35	64 600.1	5 00	512 522	8 739
36	3	6	1 107.46	.79	6	66 445.8	6 00	614 974	12 583
37	3	7	1 138.22	.79	7	68 291.6	7 00	717 397	17 126
38	3	8	1 168.99	.80	8	70 137.4	8 00	819 787	22 368
39	3	9	1 199.75	.80	9	71 983.2	9 00	922 139	28 307
23 40	30.763	40	1 230.51	1845.81	40	73 829.0	10 00	1 024 448	34 945
41	3	1	1 261.27	.81	1	75 674.8	11 00	1 126 709	42 280
42	4	2	1 292.04	.81	2	77 520.7	12 00	1 228 918	50 312
43	4	3	1 322.80	.82	3	79 366.5	13 00	1 331 070	59 041
44	4	4	1 353.56	.82	4	81 212.3	14 00	1 433 160	68 466
23 45	30.764	45	1 384.32	1845.83	45	83 058.1	15 00	1 535 183	78 588
46	4	6	1 415.09	.83	6	84 903.9	16 00	1 637 135	89 405
47	4	7	1 445.85	.83	7	86 749.8	17 00	1 739 011	100 917
48	4	8	1 476.61	.84	8	88 595.6	18 00	1 840 805	113 123
49	4	9	1 507.38	.84	9	90 441.5	19 00	1 942 514	126 023
23 50	30.764	50	1 538.14	1845.85	50	92 287.3	20 00	2 044 133	139 617
51	4	1	1 568.90	.85	1	94 133.2	21 00	2 145 657	153 903
52	4	2	1 599.66	.85	2	95 979.0	22 00	2 247 081	168 882
53	4	3	1 630.43	.86	3	97 824.9	23 00	2 348 400	184 552
54	4	4	1 661.19	.86	4	99 670.7	24 00	2 449 611	200 911
23 55	30.764	55	1 691.95	1845.87	55	101 516.6	25 00	2 550 707	217 960
56	5	6	1 722.72	.87	6	103 362.4	26 00	2 651 685	235 700
57	5	7	1 753.48	.87	7	105 208.3	27 00	2 752 540	254 127
58	5	8	1 784.24	.88	8	107 054.2	28 00	2 853 266	273 242
59	5	9	1 815.00	.88	9	108 900.1	29 00	2 953 859	293 043
23 60	30.765	60	1 845.77	1845.89	60	110 746.0	30 00	3 054 316	313 530

Latitude 24° to 25°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
24 00	28.26	56.53	84.79	113.06	141.32	169.59	197.85	226.12	254.38	1695.9	3391.8	5087.7	6783.6	8479.5
1	.26	.52	.78	.05	.30	.57	.83	.09	.35	5.7	1.4	7.0	2.7	8.4
2	.26	.52	.77	.03	.28	.55	.80	.06	.32	5.5	0.9	6.4	1.8	7.3
3	.25	.51	.76	.02	.27	.52	.78	.03	.28	5.2	0.5	5.7	1.0	6.2
4	.25	.50	.75	3.00	.25	.50	.75	6.00	.25	5.0	90.0	5.1	80.1	5.1
24 05	28.25	56.50	84.74	112.99	141.23	169.48	197.73	225.98	254.22	1694.8	3389.6	5084.4	6779.2	8474.0
6	.24	.49	.73	.97	.21	.46	.70	.95	.19	4.6	9.2	3.7	8.3	2.9
7	.24	.48	.72	.96	.19	.44	.68	.92	.16	4.4	8.7	3.1	7.4	1.8
8	.24	.47	.71	.94	.18	.41	.65	.89	.12	4.1	8.3	2.4	6.6	70.7
9	.23	.47	.70	.93	.16	.39	.63	.86	.09	3.9	7.8	1.8	5.7	69.6
24 10	28.23	56.46	84.69	112.91	141.14	169.37	197.60	225.83	254.06	1693.7	3387.4	5081.1	6774.8	8468.5
11	.23	.45	.67	.90	.12	.35	.57	.80	4.03	3.5	7.0	80.4	3.9	7.4
12	.22	.44	.66	.88	.10	.33	.55	.77	3.99	3.3	6.5	79.8	3.0	6.3
13	.22	.44	.65	.87	.09	.30	.52	.74	.96	3.0	6.1	9.1	2.2	5.2
14	.21	.43	.64	.85	.07	.28	.50	.71	.92	2.8	5.6	8.5	1.3	4.1
24 15	28.21	56.42	84.63	112.84	141.05	169.26	197.47	225.68	253.89	1692.6	3385.2	5077.8	6770.4	8463.0
16	.21	.41	.62	.83	.03	.24	.44	.65	.86	2.4	4.8	7.1	69.5	1.9
17	.20	.40	.61	.81	.01	.22	.42	.62	.82	2.2	4.3	6.5	8.6	60.8
18	.20	.40	.60	.80	1.00	.19	.39	.59	.79	1.9	3.9	5.8	7.8	59.7
19	.19	.39	.59	.78	0.98	.17	.37	.56	.75	1.7	3.4	5.2	6.9	8.6
24 20	28.19	56.38	84.57	112.77	140.96	169.15	197.34	225.53	253.72	1691.5	3383.0	5074.5	6766.0	8457.5
21	.19	.37	.56	.76	.94	.13	.31	.50	.69	1.3	2.6	3.7	5.1	6.4
22	.18	.37	.55	.74	.92	.11	.29	.47	.65	1.1	2.1	3.1	4.2	5.3
23	.18	.36	.54	.73	.90	.08	.26	.44	.62	0.8	1.7	2.5	3.3	4.1
24	.17	.35	.53	.71	.88	.06	.24	.41	.59	0.6	1.2	1.9	2.4	3.0
24 25	28.17	56.34	84.52	112.70	140.87	169.04	197.21	225.39	253.55	1690.4	3380.8	5071.2	6761.5	8451.9
26	.17	.34	.51	.68	.85	.02	.18	.36	.52	0.2	80.4	70.5	60.6	50.8
27	.16	.33	.50	.66	.83	9.00	.16	.33	.49	90.0	79.9	69.8	59.7	49.7
28	.16	.32	.49	.65	.81	8.97	.13	.30	.46	89.7	9.5	9.2	8.9	8.6
29	.16	.32	.47	.63	.79	.95	.11	.27	.42	9.5	9.0	8.5	8.0	7.5
24 30	28.15	56.31	84.46	112.62	140.77	168.93	197.08	225.24	253.39	1689.3	3378.6	5067.8	6757.1	8446.4
31	.15	.30	.45	.61	.75	.91	.05	.21	.36	9.1	8.1	7.1	6.2	5.3
32	.14	.29	.44	.59	.73	.88	.03	.18	.32	8.8	7.7	6.5	5.3	4.1
33	.14	.29	.43	.58	.72	.86	7.00	.15	.29	8.6	7.2	5.8	4.4	3.0
34	.14	.28	.42	.56	.70	.84	6.98	.12	.26	8.4	6.8	5.2	3.5	1.9
24 35	28.13	56.27	84.41	112.55	140.68	168.82	196.95	225.09	253.22	1688.2	3376.3	5064.5	6752.6	8440.8
36	.13	.26	.40	.53	.66	.79	.92	.06	.19	7.9	5.9	3.8	1.7	39.7
37	.13	.25	.39	.51	.64	.77	.90	.03	.16	7.7	5.4	3.1	0.8	8.6
38	.13	.25	.37	.50	.63	.75	.87	5.00	.13	7.5	5.0	2.5	50.0	7.4
39	.12	.24	.36	.48	.61	.72	.85	4.97	.09	7.2	4.5	1.8	49.1	6.3
24 40	28.12	56.23	84.35	112.47	140.59	168.70	196.82	224.94	253.06	1687.0	3374.1	5061.1	6748.2	8435.2
41	.11	.22	.34	.46	.57	.68	.79	.91	3.03	6.8	3.6	60.4	7.3	4.1
42	.11	.22	.33	.44	.55	.66	.77	.88	2.99	6.6	3.2	59.8	6.4	3.0
43	.11	.21	.32	.43	.53	.63	.74	.85	.96	6.3	2.7	9.1	5.5	1.8
44	.10	.20	.31	.41	.51	.61	.72	.82	.92	6.1	2.3	8.5	4.6	30.7
24 45	28.10	56.20	84.30	112.40	140.50	168.59	196.69	224.79	252.89	1685.9	3371.8	5057.8	6743.7	8429.6
46	.10	.19	.28	.38	.48	.57	.66	.76	.86	5.7	1.4	7.1	2.8	8.5
47	.09	.18	.27	.37	.46	.55	.64	.73	.82	5.5	0.9	6.4	1.9	7.3
48	.09	.17	.26	.35	.44	.52	.61	.70	.79	5.2	0.5	5.8	1.0	6.2
49	.08	.17	.25	.34	.42	.50	.59	.67	.75	5.0	70.0	5.1	40.1	5.1
24 50	28.08	56.16	84.24	112.32	140.40	168.48	196.56	224.64	252.72	1684.8	3369.6	5054.4	6739.2	8424.0
51	.08	.15	.23	.31	.38	.46	.53	.61	.69	4.6	9.1	3.7	8.3	2.8
52	.07	.14	.22	.29	.36	.43	.51	.58	.65	4.3	8.7	3.0	7.4	1.7
53	.07	.14	.21	.28	.34	.41	.48	.55	.62	4.1	8.2	2.4	6.4	20.6
54	.06	.13	.19	.26	.32	.39	.46	.52	.58	3.9	7.8	1.7	5.5	19.4
24 55	28.06	56.12	84.18	112.25	140.31	168.37	196.43	224.49	252.55	1683.7	3367.3	5051.0	6734.6	8418.3
56	.06	.11	.17	.23	.29	.34	.40	.46	.52	3.4	6.9	50.3	3.7	7.2
57	.05	.10	.16	.22	.27	.32	.38	.43	.48	3.2	6.4	49.6	2.8	6.0
58	.05	.10	.15	.20	.25	.30	.35	.40	.45	3.0	6.0	9.0	1.9	4.9
59	.04	.09	.14	.19	.23	.27	.33	.37	.41	2.7	5.5	8.3	1.0	3.8
24 60	28.04	56.08	84.13	112.17	140.21	168.25	196.30	224.34	252.38	1682.5	3365.1	5047.6	6730.1	8412.7

Lat.		Latitude 24° to 25°—Meridional arcs.						Latitude 24°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
24	00	30.765			1845.89						
	1	5	1	30.77	.89	1	1 845.9	0	1	1 695.9	0.1
	2	5	2	61.53	.89	2	3 691.8		2	3 391.8	0.4
	3	5	3	92.30	.90	3	5 537.7		3	5 087.7	0.9
	4	5	4	123.07	.90	4	7 383.6		4	6 783.6	1.6
24	05	30.765	5	153.83	1845.91	5	9 229.5	0	5	8 479.5	2.5
	6	5	6	184.60	.91	6	11 075.4		6	10 175.4	3.6
	7	5	7	215.37	.92	7	12 921.3		7	11 871.2	4.9
	8	5	8	246.13	.92	8	14 767.2		8	13 567.1	6.4
	9	5	9	276.90	.92	9	16 613.1		9	15 263.0	8.1
24	10	30.765	10	307.67	1845.93	10	18 459.1	0	10	16 958.9	10.0
	11	6	1	338.44	.93	1	20 305.0		15	25 438.4	22.6
	12	6	2	369.20	.94	2	22 150.9		20	33 917.8	40.1
	13	6	3	399.97	.94	3	23 996.9		25	42 397.2	62.7
	14	6	4	430.74	.94	4	25 842.8		30	50 876.6	90.3
24	15	30.766	15	461.50	1845.95	15	27 688.8	0	35	59 356.0	122.9
	16	6	6	492.27	.95	6	29 534.7		40	67 835.4	160.5
	17	6	7	523.04	.96	7	31 380.7		45	76 314.8	203.2
	18	6	8	553.80	.96	8	33 226.6		50	84 794.1	250.8
	19	6	9	584.57	.96	9	35 072.6		55	93 273.4	303.5
24	20	30.766	20	615.34	1845.97	20	36 918.6	1	00	101 752.7	361.2
	21	6	1	646.10	.97	1	38 764.5		05	110 231.9	423.9
	22	6	2	676.87	.98	2	40 610.5		10	118 711.1	491.6
	23	6	3	707.64	.98	3	42 456.5		15	127 190.2	564.3
	24	6	4	738.40	.98	4	44 302.5		20	135 669.3	642.1
24	25	30.766	25	769.17	1845.99	25	46 148.4	1	25	144 148.3	724.8
	26	7	6	799.94	5.99	6	47 994.4		30	152 627.4	812.6
	27	7	7	830.70	6.00	7	49 840.4		35	161 106.3	905.4
	28	7	8	861.47	.00	8	51 686.4		40	169 585.2	1 003.2
	29	7	9	892.24	.01	9	53 532.4		45	178 064.0	1 106.1
24	30	30.767	30	923.00	1846.01	30	55 378.4	1	50	186 542.8	1 213.9
	31	7	1	953.77	.01	1	57 224.4		55	195 021.5	1 326.8
	32	7	2	984.54	.02	2	59 070.5	2	00	203 500	1 445
	33	7	3	1 015.31	.02	3	60 916.5	3	00	305 237	3 250
	34	7	4	1 046.07	.03	4	62 762.5	4	00	406 959	5 778
24	35	30.767	35	1 076.84	1846.03	35	64 608.5	5	00	508 660	9 028
	36	7	6	1 107.61	.03	6	66 454.6	6	00	610 336	13 001
	37	7	7	1 138.37	.04	7	68 300.6	7	00	711 981	17 695
	38	7	8	1 169.14	.04	8	70 146.6	8	00	813 590	23 109
	39	7	9	1 199.91	.05	9	71 992.7	9	00	915 159	29 245
24	40	30.768	40	1 230.67	1846.05	40	73 838.7	10	00	1 016 681	36 102
	41	8	1	1 261.44	.05	1	75 684.8	11	00	1 118 152	43 679
	42	8	2	1 292.21	.06	2	77 530.8	12	00	1 219 566	51 977
	43	8	3	1 322.97	.06	3	79 376.9	13	00	1 320 919	60 994
	44	8	4	1 353.74	.07	4	81 223.0	14	00	1 422 205	70 731
24	45	30.768	45	1 384.51	1846.07	45	83 069.0	15	00	1 523 420	81 186
	46	8	6	1 415.27	.08	6	84 915.1	16	00	1 624 558	92 360
	47	8	7	1 446.04	.08	7	86 761.2	17	00	1 725 614	104 251
	48	8	8	1 476.81	.08	8	88 607.3	18	00	1 826 583	116 859
	49	8	9	1 507.57	.09	9	90 453.3	19	00	1 927 460	130 184
24	50	30.768	50	1 538.34	1846.09	50	92 299.4	20	00	2 028 240	144 225
	51	8	1	1 569.11	.10	1	94 145.5	21	00	2 128 918	158 981
	52	8	2	1 599.87	.10	2	95 991.6	22	00	2 229 488	174 451
	53	8	3	1 630.64	.10	3	97 837.7	23	00	2 329 946	190 634
	54	8	4	1 661.41	.11	4	99 683.8	24	00	2 430 287	207 530
24	55	30.769	55	1 692.17	1846.11	55	101 529.9	25	00	2 530 505	225 138
	56	9	6	1 722.94	.12	6	103 376.1	26	00	2 630 596	243 458
	57	9	7	1 753.71	.12	7	105 222.2	27	00	2 730 554	262 487
	58	9	8	1 784.48	.13	8	107 068.3	28	00	2 830 374	282 225
	59	9	9	1 815.24	.13	9	108 914.4	29	00	2 930 052	302 671
24	60	30.769	60	1 846.01	1846.13	60	110 760.6	30	00	3 029 582	323 825

Latitude 25° to 26°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
25 00	28.04	56.08	84.13	112.17	140.21	168.25	196.30	224.34	252.38	1682.5	3365.1	5047.6	6730.1	8412.7
1	.04	.07	.12	.16	.19	.23	.27	.31	.35	2.3	4.6	6.9	29.2	1.5
2	.03	.07	.10	.14	.17	.21	.25	.28	.31	2.1	4.2	6.2	8.3	10.4
3	.03	.06	.09	.13	.15	.18	.22	.25	.28	1.8	3.7	5.6	7.4	09.2
4	.02	.05	.08	.11	.13	.16	.19	.22	.24	1.6	3.3	4.9	6.5	8.1
25 05	28.02	56.04	84.07	112.10	140.12	168.14	196.17	224.18	252.21	1681.4	3362.8	5044.2	6725.6	8407.0
6	.02	.04	.06	.08*	.10	.12	.14	.15	.18	1.2	2.3	3.5	4.7	5.8
7	.01	.03	.05	.07	.08	.10	.11	.12	.14	1.0	1.9	2.8	3.8	4.7
8	.01	.02	.03	.05	.06	.07	.08	.09	.11	0.7	1.4	2.2	2.8	3.5
9	.01	.02	.02	.04	.04	.05	.06	.06	.07	0.5	1.0	1.5	1.9	2.4
25 10	28.00	56.01	84.01	112.02	140.02	168.03	196.03	224.03	252.04	1680.3	3360.5	5040.8	6721.0	8401.3
11	8.00	6.00	4.00	2.00	40.00	8.00	6.00	4.00	2.01	80.0	60.0	40.1	20.1	400.1
12	7.99	5.99	3.99	1.99	39.98	7.98	5.98	3.97	1.97	79.8	59.6	39.4	19.2	399.0
13	.99	.99	.98	.97	.96	.96	.95	.94	.94	9.6	9.1	8.7	8.2	7.8
14	.99	.98	.97	.96	.94	.93	.92	.91	.90	9.3	8.7	8.0	7.3	6.7
25 15	27.98	55.97	83.95	111.94	139.93	167.91	195.90	223.88	251.87	1679.1	3358.2	5037.3	6716.4	8395.5
16	.98	.96	.94	.92	.91	.89	.87	.85	.83	8.9	7.7	6.6	5.5	4.4
17	.98	.95	.93	.91	.89	.86	.84	.82	.80	8.6	7.3	5.9	4.6	3.2
18	.98	.95	.92	.89	.87	.84	.81	.79	.76	8.4	6.8	5.3	3.6	2.1
19	.97	.94	.91	.88	.85	.82	.79	.76	.73	8.2	6.4	4.6	2.7	91.0
25 20	27.97	55.93	83.90	111.86	139.83	167.80	195.76	223.73	251.69	1678.0	3355.9	5033.9	6711.8	8389.8
21	.96	.92	.89	.85	.81	.78	.73	.70	.66	7.8	5.4	3.2	0.9	8.7
22	.96	.92	.88	.83	.79	.75	.71	.67	.62	7.5	5.0	2.5	10.0	7.5
23	.96	.91	.86	.82	.77	.73	.68	.64	.59	7.3	4.5	1.8	09.0	6.3
24	.95	.90	.85	.80	.75	.70	.65	.61	.55	7.0	4.1	1.1	8.1	5.2
25 25	27.95	55.90	83.84	111.79	139.74	167.68	195.62	223.57	251.52	1676.8	3353.6	5030.4	6707.2	8384.0
26	.95	.89	.83	.77	.72	.66	.60	.54	.48	6.6	3.1	29.7	6.3	2.9
27	.94	.88	.82	.76	.70	.63	.57	.51	.45	6.3	2.7	9.0	5.4	1.7
28	.94	.87	.81	.74	.68	.61	.54	.48	.41	6.1	2.2	8.4	4.4	80.6
29	.93	.87	.79	.73	.66	.59	.52	.45	.38	5.9	1.8	7.7	3.5	79.4
25 30	27.93	55.86	83.78	111.71	139.64	167.57	195.49	223.42	251.34	1675.7	3351.3	5027.0	6702.6	8378.3
31	.93	.85	.77	.70	.62	.55	.46	.39	.31	5.5	0.8	6.3	1.7	7.1
32	.92	.84	.76	.68	.60	.52	.44	.36	.27	5.2	50.4	5.6	700.8	6.0
33	.92	.84	.75	.67	.58	.50	.41	.33	.24	5.0	49.9	4.9	699.8	4.8
34	.91	.83	.74	.65	.56	.47	.38	.30	.20	4.7	9.5	4.2	8.9	3.7
25 35	27.91	55.82	83.72	111.64	139.55	167.45	195.36	223.26	251.17	1674.5	3349.0	5023.5	6698.0	8372.5
36	.91	.81	.71	.62	.53	.43	.33	.23	.14	4.3	8.5	2.8	7.1	1.3
37	.90	.80	.70	.61	.51	.40	.30	.20	.10	4.0	8.1	2.1	6.2	70.2
38	.90	.80	.69	.59	.49	.38	.27	.17	.07	3.8	7.6	1.4	5.2	69.0
39	.89	.79	.68	.58	.47	.36	.25	.14	.03	3.6	7.2	0.7	4.3	7.9
25 40	27.89	55.78	83.67	111.56	139.45	167.33	195.22	223.11	251.00	1673.3	3346.7	5020.0	6693.4	8366.7
41	.89	.77	.66	.54	.43	.31	.19	.08	0.97	3.1	6.2	19.3	2.5	5.5
42	.88	.76	.64	.53	.41	.29	.17	.05	.93	2.9	5.7	8.6	1.5	4.4
43	.88	.76	.63	.51	.39	.26	.14	3.02	.90	2.6	5.3	7.9	90.6	3.2
44	.87	.75	.62	.50	.37	.24	.11	2.99	.86	2.4	4.8	7.2	89.6	2.0
25 45	27.87	55.74	83.61	111.48	139.35	167.22	195.09	222.95	250.82	1672.2	3344.3	5016.5	6688.7	8360.8
46	.87	.73	.60	.46	.33	.19	.06	.92	.79	1.9	3.8	5.8	7.8	59.7
47	.86	.72	.59	.45	.31	.17	.03	.89	.75	1.7	3.4	5.1	6.8	8.5
48	.86	.72	.57	.43	.29	.15	5.00	.86	.72	1.5	2.9	4.4	5.9	7.4
49	.85	.71	.56	.42	.27	.12	4.98	.83	.68	1.2	2.5	3.7	4.9	6.2
25 50	27.85	55.70	83.55	111.40	139.25	167.10	194.95	222.80	250.65	1671.0	3342.0	5013.0	6684.0	8355.0
51	.85	.69	.54	.38	.23	.08	.92	.77	.62	0.8	1.5	2.3	3.1	3.8
52	.84	.68	.53	.37	.21	.05	.90	.74	.58	0.5	1.1	1.6	2.1	2.7
53	.84	.68	.51	.35	.19	.03	.87	.71	.55	0.3	0.6	0.9	1.2	1.5
54	.83	.67	.50	.34	.17	7.01	.84	.68	.51	70.1	40.2	10.2	80.2	50.3
25 55	27.83	55.66	83.49	111.32	139.16	166.98	194.82	222.64	250.48	1669.8	3339.7	5009.5	6679.3	8349.2
56	.83	.65	.48	.30	.14	.96	.79	.61	.44	9.6	9.2	8.8	8.4	8.0
57	.82	.64	.47	.29	.12	.94	.76	.58	.41	9.4	8.7	8.1	7.4	6.8
58	.82	.64	.46	.27	.10	.91	.73	.55	.37	9.1	8.3	7.4	6.5	5.6
59	.81	.63	.44	.26	.08	.89	.71	.52	.34	8.9	7.8	6.7	5.5	4.5
25 60	27.81	55.62	83.43	111.24	139.06	166.87	194.68	222.49	250.30	1668.7	3337.3	5006.0	6674.6	8343.3

Lat.		Latitude 25° to 26°—Meridional arcs.						Latitude 25°—Co-ordinates of curvature.		
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
25	00	30.769			1846.13					
	1	9	1	30.77	.14	1	1 846.1	0 1	1 682.5	0.1
	2	9	2	61.54	.14	2	3 692.3	2	3 365.1	0.4
	3	9	3	92.31	.15	3	5 538.4	3	5 047.6	0.9
	4	9	4	123.08	.15	4	7 384.6	4	6 730.1	1.7
25	05	30.769	5	153.86	1846.15	5	9 230.7	0 5	8 412.7	2.6
	6	9	6	184.63	.16	6	11 076.9	6	10 095.2	3.7
	7	9	7	215.40	.16	7	12 923.0	7	11 777.7	5.1
	8	69	8	246.17	.17	8	14 769.2	8	13 460.3	6.6
	9	70	9	276.94	.17	9	16 615.4	9	15 142.8	8.4
25	10	30.770	10	307.71	1846.18	10	18 461.5	0 10	16 825.3	10.3
	11	0	1	338.48	.18	1	20 307.7	15	25 238.0	23.3
	12	0	2	369.25	.18	2	22 153.9	20	33 650.6	41.4
	13	0	3	400.02	.19	3	24 000.1	25	42 063.2	64.6
	14	0	4	430.79	.19	4	25 846.3	30	50 475.8	93.1
25	15	30.770	15	461.57	1846.20	15	27 692.5	0 35	58 888.4	126.7
	16	0	6	492.34	.20	6	29 538.7	40	67 301.0	165.5
	17	0	7	523.11	.21	7	31 384.9	45	75 713.5	209.4
	18	0	8	553.88	.21	8	33 231.1	50	84 126,0	258.5
	19	0	9	584.65	.21	9	35 077.3	55	92 538.5	312.8
25	20	30.770	20	615.42	1846.22	20	36 923.5	1 00	100 950.9	372.3
	21	0	1	646.19	.22	1	38 769.7	05	109 363.4	436.9
	22	0	2	676.96	.23	2	40 615.9	10	117 775.7	506.8
	23	1	3	707.73	.23	3	42 462.2	15	126 188.0	581.7
	24	1	4	738.50	.23	4	44 308.4	20	134 600.3	661.9
25	25	30.771	25	769.28	1846.24	25	46 154.6	1 25	143 012.5	747.2
	26	1	6	800.05	.24	6	48 000.9	30	151 424.7	837.7
	27	1	7	830.82	.25	7	49 847.1	35	159 836.8	933.4
	28	1	8	861.59	.25	8	51 693.4	40	168 248.9	1 034.2
	29	1	9	892.36	.26	9	53 539.6	45	176 660.9	1 140.2
25	30	30.771	30	923.13	1846.26	30	55 385.9	1 50	185 072.8	1 251.4
	31	1	1	953.90	.26	1	57 232.1	55	193 484.6	1 367.7
	32	1	2	984.67	.27	2	59 078.4	2 00	201 896	1 489
	33	1	3	1 015.44	.27	3	60 924.7	3 00	302 831	3 351
	34	1	4	1 046.21	.28	4	62 771.0	4 00	403 749	5 957
25	35	30.771	35	1 076.99	1846.28	35	64 617.2	5 00	504 645	9 307
	36	1	6	1 107.76	.29	6	66 463.5	6 00	605 514	13 401
	37	1	7	1 138.53	.29	7	68 309.8	7 00	706 349	18 239
	38	2	8	1 169.30	.29	8	70 156.1	8 00	807 146	23 821
	39	2	9	1 200.07	.30	9	72 002.4	9 00	907 899	30 146
25	40	30.772	40	1 230.84	1846.30	40	73 848.7	10 00	1 008 603	37 215
	41	2	1	1 261.61	.31	1	75 695.0	11 00	1 109 252	45 026
	42	2	2	1 292.38	.31	2	77 541.3	12 00	1 209 841	53 578
	43	2	3	1 323.15	.32	3	79 387.6	13 00	1 310 364	62 873
	44	2	4	1 353.92	.32	4	81 233.9	14 00	1 410 815	72 909
25	45	30.772	45	1 384.70	1846.32	45	83 080.3	15 00	1 511 190	83 685
	46	2	6	1 415.47	.33	6	84 926.6	16 00	1 611 483	95 202
	47	2	7	1 446.24	.33	7	86 772.9	17 00	1 711 688	107 458
	48	2	8	1 477.01	.34	8	88 619.3	18 00	1 811 800	120 453
	49	2	9	1 507.78	.34	9	90 465.6	19 00	1 911 813	134 186
25	50	30.772	50	1 538.55	1846.35	50	92 311.9	20 00	2 011 722	148 656
	51	2	1	1 569.32	.35	1	94 158.3	21 00	2 111 522	163 862
	52	3	2	1 600.09	.35	2	96 004.6	22 00	2 211 207	179 805
	53	3	3	1 630.86	.36	3	97 851.0	23 00	2 310 771	196 482
	54	3	4	1 661.63	.36	4	99 697.4	24 00	2 410 210	213 894
25	55	30.773	55	1 692.41	1846.37	55	101 543.7	25 00	2 509 518	232 038
	56	3	6	1 723.18	.37	6	103 390.1	26 00	2 608 689	250 914
	57	3	7	1 753.95	.38	7	105 236.5	27 00	2 707 718	270 521
	58	3	8	1 784.72	.38	8	107 082.8	28 00	2 806 600	290 859
	59	3	9	1 815.49	.38	9	108 929.2	29 00	2 905 329	311 925
25	60	30.773	60	1 846.26	1846.39	60	110 775.6	30 00	3 003 900	333 718

Latitude 26° to 27°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
26 00	27.81	55.62	83.43	111.24	139.06	166.87	194.68	222.49	250.30	1668.7	3337.3	5006.0	6674.6	8343.3
1	.81	.61	.42	.23	.04	.85	.65	.46	.26	8.5	6.8	5.3	3.7	2.1
2	.80	.60	.41	.21	.02	.82	.62	.43	.23	8.2	6.3	4.6	2.7	40.9
3	.80	.60	.40	.20	9.00	.80	.60	.39	.19	8.0	5.9	3.8	1.8	39.7
4	.79	.59	.39	.18	8.98	.77	.57	.36	.16	7.7	5.4	3.1	70.8	8.6
26 05	27.79	55.58	83.37	111.17	138.96	166.75	194.54	222.33	250.12	1667.5	3334.9	5002.4	6669.9	8337.4
6	.79	.57	.36	.15	.94	.73	.51	.30	.08	7.3	4.4	1.7	9.0	6.2
7	.78	.56	.35	.14	.92	.70	.48	.27	.05	7.0	4.0	1.0	8.0	5.0
8	.78	.56	.34	.12	.90	.68	.46	.23	50.01	6.8	3.5	5000.3	7.1	3.8
9	.77	.55	.33	.11	.88	.65	.43	.20	49.98	6.5	3.1	4999.6	6.1	2.7
26 10	27.77	55.54	83.31	111.09	138.86	166.63	194.40	222.17	249.94	1666.3	3332.6	4998.9	6665.2	8331.5
11	.77	.53	.30	.07	.84	.61	.37	.14	.91	6.1	2.1	8.2	4.2	30.3
12	.76	.52	.29	.06	.82	.58	.34	.11	.87	5.8	1.6	7.5	3.3	29.1
13	.76	.52	.28	.04	.80	.56	.32	.08	.84	5.6	1.2	6.7	2.3	7.9
14	.75	.51	.27	.03	.78	.53	.29	.05	.80	5.3	0.7	6.0	1.4	6.7
26 15	27.75	55.50	83.25	111.01	138.76	166.51	194.26	222.01	249.77	1665.1	3330.2	4995.3	6660.4	8325.5
16	.75	.49	.24	0.99	.74	.49	.23	1.98	.73	4.9	29.7	4.6	59.5	4.4
17	.74	.48	.23	.98	.72	.46	.20	.95	.70	4.6	9.2	3.9	8.5	3.2
18	.74	.48	.22	.96	.70	.44	.18	.92	.66	4.4	8.8	3.2	7.6	2.0
19	.73	.47	.21	.95	.68	.41	.15	.89	.63	4.1	8.3	2.5	6.6	20.8
26 20	27.73	55.46	83.20	110.93	138.66	166.39	194.12	221.86	249.59	1663.9	3327.8	4991.8	6655.7	8319.6
21	.73	.45	.18	.91	.64	.37	.09	.83	.55	3.7	7.3	1.1	4.7	8.4
22	.72	.44	.17	.90	.62	.34	.07	.80	.52	3.4	6.9	90.4	3.8	7.2
23	.72	.44	.16	.88	.60	.32	.04	.76	.48	3.2	6.4	89.6	2.8	6.0
24	.71	.43	.15	.87	.58	.29	4.01	.73	.45	2.9	6.0	8.9	1.9	4.8
26 25	27.71	55.42	83.14	110.85	138.56	166.27	193.98	221.70	249.41	1662.7	3325.5	4988.2	6650.9	8313.6
26	.71	.41	.12	.83	.54	.25	.96	.67	.37	2.5	5.0	7.5	49.9	2.4
27	.70	.40	.11	.82	.52	.22	.93	.64	.34	2.2	4.5	6.8	9.0	1.2
28	.70	.40	.10	.80	.50	.20	.90	.60	.30	2.0	4.1	6.0	8.0	10.0
29	.69	.39	.09	.79	.48	.17	.88	.57	.27	1.7	3.6	5.3	7.1	08.9
26 30	27.69	55.38	83.08	110.77	138.46	166.15	193.85	221.54	249.23	1661.5	3323.1	4984.6	6646.1	8307.7
31	.69	.37	.07	.75	.44	.13	.82	.51	.19	1.3	2.6	3.9	5.1	6.5
32	.68	.36	.05	.74	.42	.10	.79	.48	.16	1.0	2.1	3.2	4.2	5.3
33	.68	.36	.04	.72	.40	.08	.76	.44	.12	0.8	1.7	2.4	3.2	4.0
34	.67	.35	.03	.71	.38	.05	.73	.41	.09	0.5	1.2	1.7	2.3	2.8
26 35	27.67	55.34	83.02	110.69	138.36	166.03	193.71	221.38	249.05	1660.3	3320.7	4981.0	6641.3	8301.6
36	.67	.33	3.00	.67	.34	6.01	.68	.35	9.01	60.1	20.2	80.3	40.3	300.4
37	.66	.32	2.99	.66	.32	5.98	.65	.32	8.98	59.8	19.7	79.6	39.4	299.2
38	.66	.32	.98	.64	.30	.96	.62	.28	.94	9.6	9.3	8.8	8.4	8.0
39	.65	.31	.97	.63	.28	.93	.59	.25	.91	9.3	8.8	8.1	7.5	6.8
26 40	27.65	55.30	82.96	110.61	138.26	165.91	193.56	221.22	248.87	1659.1	3318.3	4977.4	6636.5	8295.6
41	.65	.29	.94	.59	.24	.89	.53	.19	.83	8.9	7.8	6.7	5.5	4.4
42	.64	.28	.93	.58	.22	.86	.50	.16	.80	8.6	7.3	6.0	4.6	3.2
43	.64	.28	.92	.56	.20	.84	.48	.12	.76	8.4	6.8	5.2	3.6	2.0
44	.63	.27	.91	.55	.18	.81	.45	.09	.73	8.1	6.3	4.5	2.7	90.8
26 45	27.63	55.26	82.90	110.53	138.16	165.79	193.42	221.06	248.69	1657.9	3315.8	4973.8	6631.7	8289.6
46	.63	.25	.88	.51	.14	.77	.39	.03	.65	7.7	5.3	3.1	30.7	8.4
47	.62	.24	.87	.50	.12	.74	.36	1.00	.62	7.4	4.8	2.3	29.7	7.2
48	.62	.24	.86	.48	.10	.72	.34	0.96	.58	7.2	4.4	1.6	8.8	6.0
49	.61	.23	.85	.47	.08	.69	.31	.93	.55	6.9	3.9	0.8	7.8	4.8
26 50	27.61	55.22	82.84	110.45	138.06	165.67	193.28	220.90	248.51	1656.7	3313.4	4970.1	6626.8	8283.6
51	.61	.21	.82	.43	.04	.65	.25	.87	.47	6.5	2.9	69.4	5.8	2.3
52	.60	.20	.81	.42	.02	.62	.22	.83	.44	6.2	2.4	8.7	4.9	81.1
53	.60	.20	.80	.40	8.00	.60	.20	.80	.40	6.0	2.0	7.9	3.9	79.9
54	.59	.19	.79	.39	7.98	.57	.17	.77	.36	5.7	1.5	7.2	3.0	8.7
26 55	27.59	55.18	82.78	110.37	137.96	165.55	193.14	220.73	248.32	1655.5	3311.0	4966.5	6622.0	8277.5
56	.59	.17	.76	.35	.94	.53	.11	.70	.29	5.3	0.5	5.8	1.0	6.3
57	.58	.16	.75	.34	.92	.50	.08	.67	.25	5.0	10.0	5.0	20.0	5.0
58	.58	.16	.74	.32	.90	.48	.06	.64	.21	4.8	09.6	4.3	19.1	3.8
59	.57	.15	.73	.31	.88	.45	.03	.60	.18	4.5	9.1	3.5	8.1	2.6
26 60	27.57	55.14	82.71	110.29	137.86	165.43	193.00	220.57	248.14	1654.3	3308.6	4962.8	6617.1	8271.4

Lat.		Latitude 26° to 27°—Meridional arcs.						Latitude 26°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
26	00	30.773			1846.39						
	1	3	1	30.78	.39	1	1 846.4	0	1	1 668.7	0.1
	2	3	2	61.55	.40	2	3 692.8		2	3 337.3	0.4
	3	3	3	92.33	.40	3	5 539.2		3	5 006.0	1.0
	4	3	4	123.10	.41	4	7 385.6		4	6 674.6	1.7
26	05	30.773	5	153.88	1846.41	5	9 232.0	0	5	8 343.3	2.7
	6	4	6	184.65	.41	6	11 078.4		6	10 011.9	3.8
	7	4	7	215.43	.42	7	12 924.8		7	11 680.6	5.2
	8	4	8	246.20	.42	8	14 771.2		8	13 349.2	6.8
	9	4	9	276.98	.43	9	16 617.7		9	15 017.9	8.6
26	10	30.774	10	307.75	1846.43	10	18 464.1	0	10	16 686.6	10.6
	11	4	1	338.53	.44	1	20 310.5		15	25 029.8	23.9
	12	4	2	369.30	.44	2	22 157.0		20	33 373.1	42.6
	13	4	3	400.08	.44	3	24 003.4		25	41 716.4	66.5
	14	4	4	430.85	.45	4	25 849.9		30	50 059.6	95.8
26	15	30.774	15	461.63	1846.45	15	27 696.3	0	35	58 402.9	130.3
	16	4	6	492.40	.46	6	29 542.8		40	66 746.1	170.2
	17	4	7	523.18	.46	7	31 389.2		45	75 089.2	215.4
	18	4	8	553.96	.47	8	33 235.7		50	83 432.4	266.0
	19	5	9	584.73	.47	9	35 082.2		55	91 775.5	321.8
26	20	30.775	20	615.51	1846.47	20	36 928.6	1	00	100 118.5	383.0
	21	5	1	646.28	.48	1	38 775.1		05	108 461.5	449.5
	22	5	2	677.06	.48	2	40 621.6		10	116 804.6	521.3
	23	5	3	707.83	.49	3	42 468.1		15	125 147.5	598.4
	24	5	4	738.61	.49	4	44 314.6		20	133 490.4	680.9
26	25	30.775	25	769.38	1846.50	25	46 161.1	1	25	141 833.2	768.7
	26	5	6	800.16	.50	6	48 007.6		30	150 176.0	861.7
	27	5	7	830.93	.51	7	49 854.1		35	158 518.7	960.2
	28	5	8	861.71	.51	8	51 700.6		40	166 861.3	1 063.9
	29	5	9	892.48	.51	9	53 547.1		45	175 203.9	1 172.9
26	30	30.775	30	923.26	1846.52	30	55 393.6	1	50	183 546.4	1 287.3
	31	5	1	954.03	.52	1	57 240.1		55	191 888.9	1 407.0
	32	5	2	984.81	.53	2	59 086.7	2	00	200 231	1 532
	33	6	3	1 015.59	.53	3	60 933.2	3	00	300 332	3 447
	34	6	4	1 046.36	.54	4	62 779.7	4	00	400 416	6 128
26	35	30.776	35	1 077.14	1846.54	35	64 626.2	5	00	500 476	9 574
	36	6	6	1 107.91	.54	6	66 472.8	6	00	600 506	13 786
	37	6	7	1 138.69	.55	7	68 319.3	7	00	700 501	18 763
	38	6	8	1 169.46	.55	8	70 165.9	8	00	800 456	24 505
	39	6	9	1 200.24	.56	9	72 012.4	9	00	900 364	31 011
26	40	30.776	40	1 231.01	1846.56	40	73 859.0	10	00	1 000 218	38 282
	41	6	1	1 261.79	.57	1	75 705.6	11	00	1 100 015	46 316
	42	6	2	1 292.56	.57	2	77 552.1	12	00	1 199 747	55 114
	43	6	3	1 323.34	.58	3	79 398.7	13	00	1 299 409	64 675
	44	6	4	1 354.11	.58	4	81 245.3	14	00	1 398 994	74 998
26	45	30.776	45	1 384.89	1846.58	45	83 091.9	15	00	1 498 498	86 082
	46	6	6	1 415.66	.59	6	84 938.4	16	00	1 597 914	97 928
	47	7	7	1 446.44	.59	7	86 785.0	17	00	1 697 237	110 534
	48	7	8	1 477.21	.60	8	88 631.6	18	00	1 796 460	123 899
	49	7	9	1 507.99	.60	9	90 478.2	19	00	1 895 578	138 023
26	50	30.777	50	1 538.77	1846.61	50	92 324.8	20	00	1 994 585	152 905
	51	7	1	1 569.54	.61	1	94 171.4	21	00	2 093 475	168 544
	52	7	2	1 600.32	.61	2	96 018.1	22	00	2 192 243	184 939
	53	7	3	1 631.09	.62	3	97 864.7	23	00	2 290 882	202 089
	54	7	4	1 661.87	.62	4	99 711.3	24	00	2 389 387	219 993
26	55	30.777	55	1 692.64	1846.63	55	101 557.9	25	00	2 487 753	238 650
	56	7	6	1 723.42	.63	6	103 404.6	26	00	2 585 973	258 061
	57	7	7	1 754.19	.64	7	105 251.2	27	00	2 684 042	278 222
	58	7	8	1 784.97	.64	8	107 097.8	28	00	2 781 953	299 132
	59	7	9	1 815.74	.65	9	108 944.5	29	00	2 879 702	320 788
26	60	30.777	60	1 846.52	1846.65	60	110 791.1	30	00	2 977 281	343 197

Latitude 27° to 28°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
27 00	27.57	55.14	82.71	110.29	137.86	165.43	193.00	220.57	248.14	1654.3	3308.6	4962.8	6617.1	8271.4
1	.57	.13	.70	.27	.84	.41	2.97	.54	.10	4.1	8.1	2.1	6.1	70.2
2	.56	.12	.69	.26	.82	.38	.94	.50	.07	3.8	7.6	1.4	5.1	68.9
3	.56	.12	.68	.24	.80	.35	.91	.47	8.03	3.5	7.1	60.6	4.2	7.7
4	.55	.11	.66	.22	.78	.33	.88	.44	7.99	3.3	6.6	59.9	3.2	6.5
27 05	27.55	55.10	82.65	110.21	137.76	165.31	192.86	220.40	247.96	1653.1	3306.1	4959.2	6612.2	8265.3
6	.55	.09	.64	.19	.73	.28	.83	.37	.92	2.8	5.6	8.5	1.2	4.1
7	.54	.08	.63	.17	.71	.26	.80	.34	.88	2.6	5.1	7.7	10.2	2.8
8	.54	.08	.62	.15	.69	.23	.77	.31	.84	2.3	4.7	6.9	09.3	1.6
9	.53	.07	.60	.14	.67	.21	.74	.27	.81	2.1	4.2	6.2	8.3	60.4
27 10	27.53	55.06	82.59	110.12	137.65	165.18	192.71	220.24	247.77	1651.8	3303.7	4955.5	6607.3	8259.2
11	.53	.05	.58	.10	.63	.16	.68	.21	.73	1.6	3.2	4.8	6.3	7.9
12	.52	.04	.57	.09	.61	.13	.65	.18	.70	1.3	2.7	4.0	5.3	6.7
13	.52	.04	.55	.08	.59	.11	.63	.14	.66	1.1	2.2	3.3	4.4	5.5
14	.51	.03	.54	.06	.57	.08	.60	.11	.63	0.8	1.7	2.5	3.4	4.2
27 15	27.51	55.02	82.53	110.04	137.55	165.06	192.57	220.08	247.59	1650.6	3301.2	4951.8	6602.4	8253.0
16	.51	.01	.52	.03	.53	.04	.54	.05	.55	0.4	0.7	1.1	1.4	1.8
17	.50	.00	.51	10.01	.51	5.01	.51	20.02	.52	50.1	300.2	50.3	600.4	50.6
18	.50	5.00	.49	09.99	.49	4.99	.49	19.98	.48	49.9	299.7	49.6	599.5	49.3
19	.49	4.99	.48	.98	.47	.96	.46	.95	.45	9.6	9.2	8.8	8.5	8.1
27 20	27.49	54.98	82.47	109.96	137.45	164.94	192.43	219.92	247.41	1649.4	3298.7	4948.1	6597.5	8246.9
21	.49	.97	.46	.94	.43	.91	.40	.89	.37	9.1	8.2	7.4	6.5	5.6
22	.48	.96	.44	.93	.41	.89	.37	.85	.33	8.9	7.7	6.6	5.5	4.4
23	.48	.96	.43	.91	.39	.86	.34	.82	.30	8.6	7.3	5.9	4.5	3.2
24	.47	.95	.42	.89	.37	.84	.31	.79	.26	8.4	6.8	5.1	3.5	1.9
27 25	27.47	54.94	82.41	109.88	137.34	164.81	192.29	219.75	247.22	1648.1	3296.3	4944.4	6592.5	8240.7
26	.47	.93	.39	.86	.32	.79	.26	.72	.18	7.9	5.8	3.7	1.5	39.4
27	.46	.92	.38	.84	.30	.76	.23	.69	.14	7.6	5.3	2.9	90.5	8.2
28	.46	.92	.37	.82	.28	.74	.20	.66	.11	7.4	4.8	2.2	89.6	7.0
29	.45	.91	.36	.81	.26	.71	.17	.62	.07	7.1	4.3	1.4	8.6	5.7
27 30	27.45	54.90	82.34	109.79	137.24	164.69	192.14	219.59	247.03	1646.9	3293.8	4940.7	6587.6	8234.5
31	.45	.89	.33	.77	.22	.67	.11	.56	6.99	6.7	3.3	40.0	6.6	3.3
32	.44	.88	.32	.76	.20	.64	.08	.52	.96	6.4	2.8	39.2	5.6	2.0
33	.44	.87	.31	.74	.18	.62	.05	.49	.92	6.2	2.3	8.5	4.6	30.8
34	.43	.86	.29	.73	.16	.59	.02	.46	.88	5.9	1.8	7.7	3.6	29.5
27 35	27.43	54.86	82.28	109.71	137.13	164.57	192.00	219.42	246.84	1645.7	3291.3	4937.0	6582.6	8228.3
36	.43	.85	.27	.69	.11	.54	1.97	.39	.81	5.4	0.8	6.2	1.6	7.0
37	.42	.84	.26	.68	.09	.52	.94	.36	.77	5.2	90.3	5.5	80.6	5.8
38	.42	.83	.24	.66	.07	.49	.91	.33	.73	4.9	89.8	4.7	79.6	4.5
39	.41	.82	.23	.65	.05	.47	.88	.29	.70	4.7	9.3	4.0	8.6	3.3
27 40	27.41	54.81	82.22	109.63	137.03	164.44	191.85	219.26	246.66	1644.4	3288.8	4933.2	6577.6	8222.1
41	.40	.80	.21	.61	7.01	.42	.82	.23	.62	4.2	8.3	2.5	6.6	20.8
42	.40	.79	.20	.60	6.99	.39	.79	.19	.59	3.9	7.8	1.7	5.6	19.6
43	.40	.79	.18	.58	.97	.37	.76	.16	.55	3.7	7.3	1.0	4.6	8.3
44	.39	.78	.17	.56	.95	.34	.73	.12	.51	3.4	6.8	30.2	3.6	7.1
27 45	27.39	54.77	82.16	109.55	136.93	164.32	191.71	219.09	246.48	1643.2	3286.3	4929.5	6572.6	8215.8
46	.38	.76	.15	.53	.91	.29	.68	.06	.44	2.9	5.8	8.7	1.6	4.6
47	.38	.75	.13	.51	.89	.27	.65	9.02	.40	2.7	5.3	8.0	70.6	3.3
48	.38	.75	.12	.49	.87	.24	.62	8.99	.36	2.4	4.8	7.2	69.6	2.1
49	.37	.74	.11	.48	.85	.22	.59	.95	.33	2.2	4.3	6.5	8.6	10.8
27 50	27.37	54.73	82.10	109.46	136.83	164.19	191.56	218.92	246.29	1641.9	3283.8	4925.7	6567.6	8209.6
51	.36	.72	.08	.44	.81	.17	.53	.89	.25	1.7	3.3	5.0	6.6	8.3
52	.36	.71	.07	.43	.79	.14	.50	.85	.21	1.4	2.8	4.2	5.6	7.0
53	.36	.71	.06	.41	.77	.12	.47	.82	.18	1.2	2.3	3.5	4.6	5.8
54	.35	.70	.05	.39	.75	.09	.44	.79	.14	0.9	1.8	2.7	3.6	4.5
27 55	27.35	54.69	82.03	109.38	136.72	164.07	191.41	218.75	246.10	1640.7	3281.3	4922.0	6562.6	8203.3
56	.34	.68	.02	.36	.70	.04	.38	.72	.06	0.4	0.8	1.2	1.6	2.0
57	.34	.67	.01	.34	.68	4.02	.35	.69	6.02	40.2	80.3	20.5	60.6	200.7
58	.33	.67	2.00	.32	.66	3.99	.32	.66	5.99	39.9	79.8	19.7	59.6	199.5
59	.33	.66	1.98	.31	.64	.96	.29	.62	.95	9.6	9.3	8.9	8.6	8.2
27 60	27.32	54.65	81.97	109.29	136.62	163.94	191.26	218.59	245.91	1639.4	3278.8	4918.2	6557.6	8197.0

Lat.		Latitude 27° to 28°—Meridional arcs.						Latitude 27°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
27	00	30.777			1846.65						
	1	8	1	30.78	.65	1	1 846.7	0	1	1 654.3	0.1
	2	8	2	61.56	.66	2	3 693.3		2	3 308.5	0.4
	3	8	3	92.34	.66	3	5 540.0		3	4 962.8	1.0
	4	8	4	123.12	.67	4	7 386.6		4	6 617.1	1.7
27	05	30.778	5	153.90	1846.67	5	9 233.3	0	5	8 271.4	2.7
	6	8	6	184.68	.68	6	11 080.0		6	9 925.7	3.9
	7	8	7	215.46	.68	7	12 926.7		7	11 579.9	5.4
	8	8	8	246.24	.69	8	14 773.3		8	13 234.2	7.0
	9	8	9	277.02	.69	9	16 620.0		9	14 888.5	8.8
27	10	30.778	10	307.80	1846.69	10	18 466.7	0	10	16 542.8	10.9
	11	8	1	338.58	.70	1	20 313.4		15	24 814.1	24.6
	12	8	2	369.36	.70	2	22 160.1		20	33 085.5	43.7
	13	8	3	400.14	.71	3	24 006.8		25	41 356.9	68.3
	14	9	4	430.92	.71	4	25 853.5		30	49 628.2	98.3
27	15	30.779	15	461.70	1846.72	15	27 700.2	0	35	57 899.5	133.8
	16	9	6	492.48	.72	6	29 547.0		40	66 170.8	174.8
	17	9	7	523.26	.73	7	31 393.7		45	74 442.1	221.2
	18	9	8	554.04	.73	8	33 240.4		50	82 713.3	273.1
	19	9	9	584.81	.73	9	35 087.2		55	90 984.5	330.4
27	20	30.779	20	615.59	1846.74	20	36 933.9	1	00	99 255.7	393.2
	21	9	1	646.37	.74	1	38 780.6		05	107 526.8	461.5
	22	9	2	677.15	.75	2	40 627.4		10	115 797.9	535.2
	23	9	3	707.93	.75	3	42 474.1		15	124 068.9	614.4
	24	9	4	738.71	.76	4	44 320.9		20	132 339.9	699.1
27	25	30.779	25	769.49	1846.76	25	46 167.6	1	25	140 610.8	789.2
	26	9	6	800.27	.77	6	48 014.4		30	148 881.6	884.8
	27	9	7	831.05	.77	7	49 861.2		35	157 152.3	985.8
	28	80	8	861.83	.77	8	51 707.9		40	165 423.1	1 092.3
	29	0	9	892.61	.78	9	53 554.7		45	173 693.7	1 204.3
27	30	30.780	30	923.39	1846.78	30	55 401.5	1	50	181 964.3	1 321.7
	31	0	1	954.17	.79	1	57 248.3		55	190 234.7	1 444.6
	32	0	2	984.95	.79	2	59 095.1	2	00	198 505	1 573
	33	0	3	1 015.73	.80	3	60 941.9	3	00	297 742	3 539
	34	0	4	1 046.51	.80	4	62 788.7	4	00	396 960	6 291
27	35	30.780	35	1 077.29	1846.81	35	64 635.5	5	00	496 154	9 829
	36	0	6	1 108.07	.81	6	66 482.3	6	00	595 316	14 154
	37	0	7	1 138.85	.81	7	68 329.1	7	00	694 440	19 264
	38	0	8	1 169.63	.82	8	70 175.9	8	00	793 522	25 159
	39	0	9	1 200.41	.82	9	72 022.7	9	00	892 554	31 839
27	40	30.780	40	1 231.19	1846.83	40	73 869.6	10	00	991 529	39 303
	41	1	1	1 261.97	.83	1	75 716.4	11	00	1 090 442	47 551
	42	1	2	1 292.75	.84	2	77 563.2	12	00	1 189 287	56 583
	43	1	3	1 323.53	.84	3	79 410.1	13	00	1 288 057	66 398
	44	1	4	1 354.31	.85	4	81 256.9	14	00	1 386 746	76 995
27	45	30.781	45	1 385.09	1846.85	45	83 103.7	15	00	1 485 348	88 374
	46	1	6	1 415.87	.86	6	84 950.6	16	00	1 583 857	100 534
	47	1	7	1 446.65	.86	7	86 797.5	17	00	1 682 267	113 474
	48	1	8	1 477.43	.86	8	88 644.3	18	00	1 780 570	127 193
	49	1	9	1 508.21	.87	9	90 491.2	19	00	1 878 762	141 690
27	50	30.781	50	1 538.99	1846.87	50	92 338.1	20	00	1 976 836	156 966
	51	1	1	1 569.77	.88	1	94 184.9	21	00	2 074 786	173 018
	52	1	2	1 600.55	.88	2	96 031.8	22	00	2 172 606	189 845
	53	1	3	1 631.33	.89	3	97 878.7	23	00	2 270 289	207 447
	54	2	4	1 662.11	.89	4	99 725.6	24	00	2 367 830	225 823
27	55	30.782	55	1 692.88	1846.90	55	101 572.5	25	00	2 465 222	244 970
	56	2	6	1 723.66	.90	6	103 419.4	26	00	2 562 459	264 889
	57	2	7	1 754.44	.90	7	105 266.3	27	00	2 659 535	285 577
	58	2	8	1 785.22	.91	8	107 113.2	28	00	2 756 445	307 035
	59	2	9	1 816.00	.91	9	108 960.1	29	00	2 853 181	329 259
27	60	30.782	60	1 846.78	1846.92	60	110 807.0	30	00	2 949 739	352 249

Latitude 28° to 29°—Arcs of the parallel in meters.

Lat. ° ′	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
28 00	27.32	54.65	81.97	109.29	136.62	163.94	191.26	218.59	245.91	1639.4	3278.8	4918.2	6557.6	8197.0
1	.32	.64	.96	.27	.60	.91	.23	.56	.87	9.1	8.3	7.4	6.6	5.7
2	.31	.63	.94	.26	.58	.89	.20	.52	.83	8.9	7.8	6.7	5.6	4.4
3	.31	.62	.93	.24	.56	.86	.17	.49	.80	8.6	7.3	5.9	4.5	3.2
4	.30	.61	.92	.22	.54	.84	.14	.45	.76	8.4	6.8	5.2	3.5	1.9
28 05	27.30	54.60	81.91	109.21	136.51	163.81	191.12	218.42	245.72	1638.1	3276.3	4914.4	6552.5	8190.7
6	.30	.60	.89	.19	.49	.79	.09	.39	.68	7.9	5.8	3.6	1.5	89.4
7	.29	.59	.88	.17	.47	.76	.06	.35	.66	7.6	5.3	2.9	50.5	8.1
8	.29	.58	.87	.15	.45	.74	.03	.32	.61	7.4	4.7	2.1	49.5	6.9
9	.28	.57	.86	.14	.43	.71	1.00	.28	.57	7.1	4.2	1.4	8.5	5.6
28 10	27.28	54.56	81.84	109.12	136.41	163.69	190.97	218.25	245.53	1636.9	3273.7	4910.6	6547.5	8184.3
11	.28	.55	.83	.10	.39	.66	.94	.22	.49	6.6	3.2	09.8	6.5	3.1
12	.27	.54	.82	.09	.37	.64	.91	.18	.45	6.4	2.7	9.1	5.4	1.8
13	.27	.54	.80	.07	.34	.61	.88	.15	.42	6.1	2.2	8.5	4.4	80.5
14	.26	.53	.79	.05	.32	.59	.85	.11	.38	5.9	1.7	7.6	3.4	79.3
28 15	27.26	54.52	81.78	109.04	136.30	163.56	190.82	218.08	245.34	1635.6	3271.2	4906.8	6542.4	8178.0
16	.26	.51	.77	.02	.28	.53	.79	.05	.30	5.3	0.7	6.0	1.4	6.7
17	.25	.50	.75	9.00	.26	.51	.76	8.01	.26	5.1	70.2	5.3	40.3	5.4
18	.25	.50	.74	8.98	.23	.48	.73	7.98	.23	4.8	69.6	4.5	39.3	4.2
19	.24	.49	.73	.97	.21	.46	.70	.94	.19	4.6	9.1	3.8	8.3	2.9
28 20	27.24	54.48	81.72	108.95	136.19	163.43	190.67	217.91	245.15	1634.3	3268.6	4903.0	6537.3	8171.6
21	.24	.47	.70	.93	.17	.41	.64	.88	.11	4.1	8.1	2.2	6.3	70.3
22	.23	.46	.69	.92	.15	.38	.61	.84	.07	3.8	7.6	1.4	5.2	69.1
23	.23	.45	.68	.90	.13	.36	.58	.81	.03	3.6	7.1	900.7	4.2	7.8
24	.22	.44	.67	.88	.11	.33	.55	.77	5.01	3.3	6.6	899.9	3.2	6.5
28 25	27.22	54.44	81.65	108.87	136.08	163.30	190.52	217.74	244.96	1633.0	3266.1	4899.1	6532.2	8165.2
26	.22	.43	.64	.85	.06	.28	.49	.71	.92	2.8	5.6	8.3	1.2	3.9
27	.21	.42	.63	.83	.04	.25	.46	.67	.88	2.5	5.1	7.6	30.1	2.7
28	.21	.41	.61	.81	.02	.23	.43	.64	.84	2.3	4.5	6.8	29.1	1.4
29	.20	.40	.60	.80	6.00	.20	.40	.60	.80	2.0	4.0	6.1	8.1	60.1
28 30	27.20	54.39	81.59	108.78	135.98	163.18	190.37	217.57	244.76	1631.8	3263.5	4895.3	6527.1	8158.8
31	.19	.38	.58	.76	.96	.15	.34	.54	.72	1.5	3.0	4.5	6.0	7.5
32	.19	.37	.56	.75	.94	.13	.31	.50	.68	1.3	2.5	3.7	5.0	6.3
33	.19	.37	.55	.73	.92	.10	.28	.47	.65	1.0	2.0	3.0	4.0	5.0
34	.18	.36	.54	.71	.90	.08	.25	.43	.61	0.8	1.5	2.2	2.9	3.7
28 35	27.18	54.35	81.52	108.70	135.87	163.05	190.22	217.40	244.57	1630.5	3261.0	4891.4	6521.9	8152.4
36	.17	.34	.51	.68	.85	.02	.19	.37	.53	0.2	0.5	90.6	20.9	51.1
37	.17	.33	.50	.66	.83	3.00	.16	.33	.49	30.0	60.0	89.9	19.9	49.8
38	.16	.33	.49	.64	.81	2.97	.13	.30	.46	29.7	59.4	9.1	8.8	8.5
39	.16	.32	.47	.63	.79	.95	.10	.26	.42	9.5	8.9	8.4	7.8	7.3
28 40	27.15	54.31	81.46	108.61	135.77	162.92	190.07	217.23	244.38	1629.2	3258.4	4887.6	6516.8	8146.0
41	.15	.30	.45	.59	.75	.89	.04	.20	.34	8.9	7.9	6.8	5.7	4.7
42	.14	.29	.43	.58	.73	.87	90.01	.16	.30	8.7	7.4	6.0	4.7	3.4
43	.14	.28	.42	.56	.70	.84	89.98	.13	.26	8.4	6.8	5.3	3.7	2.1
44	.13	.27	.41	.54	.68	.82	.95	.09	.22	8.2	6.3	4.5	2.6	40.8
28 45	27.13	54.27	81.40	108.53	135.66	162.79	189.92	217.06	244.18	1627.9	3255.8	4883.7	6511.6	8139.5
46	.13	.26	.38	.51	.64	.76	.89	7.02	.15	7.6	5.3	2.9	10.6	8.2
47	.12	.25	.37	.49	.62	.74	.86	6.99	.11	7.4	4.8	2.1	09.5	6.9
48	.12	.24	.36	.47	.59	.71	.83	.95	.07	7.1	4.2	1.4	8.5	5.6
49	.11	.23	.34	.46	.57	.69	.80	.92	4.03	6.9	3.7	80.6	7.5	4.4
28 50	27.11	54.22	81.33	108.44	135.55	162.66	189.77	216.88	243.99	1626.6	3253.2	4879.8	6506.4	8133.1
51	.11	.21	.32	.42	.53	.64	.74	.85	.95	6.4	2.7	9.1	5.4	1.8
52	.10	.20	.30	.41	.51	.61	.71	.81	.91	6.1	2.2	8.2	4.4	30.5
53	.10	.19	.29	.39	.48	.58	.68	.78	.87	5.8	1.6	7.5	3.3	29.2
54	.09	.18	.28	.37	.46	.56	.65	.74	.83	5.6	1.1	6.7	2.3	7.9
28 55	27.09	54.18	81.27	108.36	135.44	162.53	189.62	216.71	243.80	1625.3	3250.6	4875.9	6501.2	8126.6
56	.09	.17	.25	.34	.42	.51	.59	.68	.76	5.1	50.1	5.2	500.2	5.3
57	.08	.16	.24	.32	.40	.48	.56	.64	.72	4.8	49.6	4.3	499.2	4.0
58	.08	.15	.23	.30	.37	.45	.53	.61	.68	4.5	9.0	3.6	8.1	2.7
59	.07	.14	.21	.29	.35	.43	.50	.57	.64	4.3	8.5	2.8	7.1	1.4
28 60	27.07	54.13	81.20	108.27	135.33	162.40	189.47	216.54	243.60	1624.0	3248.0	4872.0	6496.1	8120.1

Lat.		Latitude 28° to 29°—Meridional arcs.						Latitude 28°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
28	00	30.782			1846.92						
	1	2	1	30.78	.92	1	1 846.9	0	1	1 639.4	0.1
	2	2	2	61.57	.93	2	3 693.8		2	3 278.8	0.4
	3	2	3	92.35	.93	3	5 540.8		3	4 918.2	1.0
	4	2	4	123.14	.94	4	7 387.7		4	6 557.6	1.8
28	05	30.782	5	153.92	1846.94	5	9 234.6	0	5	8 197.0	2.8
	6	2	6	184.71	.95	6	11 081.6		6	9 836.4	4.0
	7	2	7	215.49	.95	7	12 928.5		7	11 475.7	5.5
	8	3	8	246.27	.95	8	14 775.5		8	13 115.1	7.2
	9	3	9	277.06	.96	9	16 622.5		9	14 754.5	9.1
28	10	30.783	10	307.84	1846.96	10	18 469.4	0	10	16 393.9	11.2
	11	3	1	338.63	.97	1	20 316.4		15	24 590.9	25.2
	12	3	2	369.41	.97	2	22 163.3		20	32 787.9	44.8
	13	3	3	400.20	.98	3	24 010.3		25	40 984.8	70.0
	14	3	4	430.98	.98	4	25 857.3		30	49 181.7	100.7
28	15	30.783	15	461.76	1846.99	15	27 704.3	0	35	57 378.6	137.1
	16	3	6	492.55	6.99	6	29 551.3		40	65 575.5	179.1
	17	3	7	523.33	7.00	7	31 398.3		45	73 772.4	226.7
	18	3	8	554.12	.00	8	33 245.3		50	81 969.2	279.8
	19	3	9	584.90	.00	9	35 092.3		55	90 165.9	338.6
28	20	30.783	20	615.69	1847.01	20	36 939.3	1	00	98 362.6	403.0
	21	4	1	646.47	.01	1	38 786.3		05	106 559.3	472.9
	22	4	2	677.25	.02	2	40 633.3		10	114 756.0	548.5
	23	4	3	708.04	.02	3	42 480.3		15	122 952.5	629.6
	24	4	4	738.82	.03	4	44 327.4		20	131 149.0	716.4
28	25	30.784	25	769.61	1847.03	25	46 174.4	1	25	139 345.5	808.7
	26	4	6	800.39	.04	6	48 021.4		30	147 541.9	906.7
	27	4	7	831.17	.04	7	49 868.5		35	155 738.2	1 010.2
	28	4	8	861.96	.05	8	51 715.5		40	163 934.5	1 119.4
	29	4	9	892.74	.05	9	53 562.5		45	172 130.7	1 234.1
28	30	30.784	30	923.53	1847.06	30	55 409.6	1	50	180 326.8	1 354.4
	31	4	1	954.31	.06	1	57 256.7		55	188 522.8	1 480.4
	32	4	2	985.10	.06	2	59 103.7	2	00	196 719	1 612
	33	4	3	1 015.88	.07	3	60 950.8	3	00	295 062	3 627
	34	5	4	1 046.66	.07	4	62 797.9	4	00	393 385	6 447
28	35	30.785	35	1 077.45	1847.08	35	64 644.9	5	00	491 682	10 073
	36	5	6	1 108.23	.08	6	66 492.0	6	00	589 945	14 505
	37	5	7	1 139.02	.09	7	68 339.1	7	00	688 168	19 741
	38	5	8	1 169.80	.09	8	70 186.2	8	00	786 347	25 782
	39	5	9	1 200.59	.10	9	72 033.3	9	00	884 472	32 627
28	40	30.785	40	1 231.37	1847.10	40	73 880.4	10	00	982 537	40 276
	41	5	1	1 262.15	.11	1	75 727.5	11	00	1 080 537	48 728
	42	5	2	1 292.94	.11	2	77 574.6	12	00	1 178 464	57 983
	43	5	3	1 323.72	.11	3	79 421.7	13	00	1 276 312	68 040
	44	5	4	1 354.51	.12	4	81 268.8	14	00	1 374 075	78 899
28	45	30.785	45	1 385.29	1847.12	45	83 115.9	15	00	1 471 745	90 558
	46	5	6	1 416.08	.13	6	84 963.1	16	00	1 569 315	103 017
	47	6	7	1 446.86	.13	7	86 810.2	17	00	1 666 781	116 275
	48	6	8	1 477.64	.14	8	88 657.3	18	00	1 764 135	130 331
	49	6	9	1 508.43	.14	9	90 504.5	19	00	1 861 371	145 185
28	50	30.786	50	1 539.21	1847.15	50	92 351.6	20	00	1 958 481	160 835
	51	6	1	1 570.00	.15	1	94 198.8	21	00	2 055 460	177 280
	52	6	2	1 600.78	.16	2	96 045.9	22	00	2 152 302	194 518
	53	6	3	1 631.57	.16	3	97 893.1	23	00	2 248 998	212 550
	54	6	4	1 662.35	.17	4	99 740.2	24	00	2 345 544	231 374
28	55	30.786	55	1 693.13	1847.17	55	101 587.4	25	00	2 441 932	250 988
	56	6	6	1 723.92	.17	6	103 434.6	26	00	2 538 156	271 391
	57	6	7	1 754.70	.18	7	105 281.8	27	00	2 634 210	292 582
	58	6	8	1 785.49	.18	8	107 128.9	28	00	2 730 087	314 559
	59	6	9	1 816.27	.19	9	108 976.1	29	00	2 825 779	337 321
28	60	30.787	60	1 847.06	1847.19	60	110 823.3	30	00	2 921 284	360 866

Latitude 29° to 30°—arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
29 00	27.07	54.13	81.20	108.27	135.33	162.40	189.47	216.54	243.60	1624.0	3248.0	4872.0	6496.1	8120.1
1	.06	.12	.19	.25	.31	.38	.44	.50	.56	3.8	7.5	1.2	5.0	18.8
2	.06	.11	.17	.23	.29	.35	.41	.47	.52	3.5	7.0	70.4	4.0	7.5
3	.06	.11	.16	.22	.27	.32	.38	.43	.48	3.2	6.4	69.7	2.9	6.1
4	.05	.10	.15	.20	.25	.30	.35	.40	.44	3.0	5.9	8.9	1.9	4.8
29 05	27.05	54.09	81.13	108.18	135.22	162.27	189.31	216.36	243.40	1622.7	3245.4	4868.1	6490.8	8113.5
6	.04	.08	.12	.16	.20	.24	.28	.33	.37	2.4	4.9	7.3	89.8	2.2
7	.04	.07	.11	.14	.18	.22	.25	.29	.33	2.2	4.4	6.5	8.7	10.9
8	.03	.07	.10	.13	.16	.19	.22	.26	.29	1.9	3.8	5.8	7.7	09.6
9	.03	.06	.08	.11	.14	.17	.19	.22	.25	1.7	3.3	5.0	6.6	8.3
29 10	27.02	54.05	81.07	108.09	135.12	162.14	189.16	216.19	243.21	1621.4	3242.8	4864.2	6485.6	8107.0
11	.02	.04	.06	.07	.10	.11	.13	.15	.17	1.1	2.3	3.4	4.6	5.7
12	.01	.03	.04	.06	.08	.09	.10	.12	.13	0.9	1.8	2.6	3.5	4.4
13	.01	.02	.03	.04	.05	.06	.07	.08	.09	0.6	1.2	1.9	2.5	3.1
14	.00	.01	.02	.02	.03	.03	.04	.05	.05	0.3	0.7	1.1	1.4	1.7
29 15	27.00	54.00	81.00	108.00	135.01	162.01	189.01	216.01	243.02	1620.1	3240.2	4860.3	6480.4	8100.4
16	7.00	4.00	0.99	7.99	4.99	1.98	8.98	5.98	2.97	19.8	39.6	59.5	79.3	099.1
17	6.99	3.99	.98	.97	.97	.96	.95	.94	.93	9.6	9.1	8.7	8.3	7.8
18	.99	.98	.97	.95	.94	.93	.92	.91	.90	9.3	8.6	7.9	7.2	6.5
19	.98	.97	.95	.94	.92	.90	.89	.87	.86	9.0	8.1	7.1	6.2	5.2
29 20	26.98	53.96	80.94	107.92	134.90	161.88	188.86	215.84	242.82	1618.8	3237.6	4856.3	6475.1	8093.9
21	.98	.95	.93	.90	.88	.85	.83	.80	.78	8.5	7.0	5.5	4.1	2.6
22	.97	.94	.91	.88	.85	.82	.80	.77	.74	8.2	6.5	4.7	3.0	91.2
23	.97	.93	.90	.87	.83	.80	.77	.73	.70	8.0	6.0	4.0	1.9	89.9
24	.96	.92	.89	.85	.81	.77	.74	.70	.66	7.7	5.4	3.2	70.9	8.6
29 25	26.96	53.91	80.87	107.83	134.79	161.75	188.70	215.66	242.62	1617.5	3234.9	4852.4	6469.8	8087.3
26	.96	.91	.86	.81	.77	.72	.67	.62	.58	7.2	4.4	1.6	8.8	6.0
27	.95	.90	.85	.79	.75	.69	.64	.59	.54	6.9	3.8	0.8	7.7	4.6
28	.95	.89	.83	.78	.72	.67	.61	.55	.50	6.7	3.3	50.0	6.6	3.3
29	.94	.88	.82	.76	.70	.64	.58	.52	.46	6.4	2.8	49.2	5.6	2.0
29 30	26.94	53.87	80.81	107.74	134.68	161.61	188.55	215.48	242.42	1616.1	3232.3	4848.4	6464.5	8080.7
31	.93	.86	.79	.72	.66	.59	.52	.45	.38	5.9	1.8	7.6	3.5	79.4
32	.93	.85	.78	.71	.64	.56	.49	.41	.34	5.6	1.2	6.8	2.4	8.0
33	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	0.7	6.0	1.4	6.7
34	.92	.83	.75	.67	.59	.51	.43	.34	.26	5.1	30.2	5.2	60.3	5.4
29 35	26.91	53.83	80.74	107.66	134.57	161.48	188.39	215.31	242.22	1614.8	3229.6	4844.4	6459.2	8074.0
36	.91	.82	.73	.64	.55	.45	.36	.27	.18	4.5	9.1	3.6	8.2	2.7
37	.90	.81	.71	.62	.53	.43	.33	.24	.14	4.3	8.6	2.8	7.1	1.4
38	.90	.80	.70	.60	.50	.40	.30	.20	.10	4.0	8.0	2.0	6.0	70.1
39	.90	.79	.69	.59	.48	.37	.27	.17	.06	3.7	7.5	1.2	5.0	68.7
29 40	26.89	53.78	80.67	107.57	134.46	161.35	188.24	215.13	242.02	1613.5	3227.0	4840.4	6453.9	8067.4
41	.89	.77	.66	.55	.44	.32	.21	.10	1.98	3.2	6.4	39.6	2.9	6.1
42	.88	.76	.65	.53	.41	.29	.18	.06	.94	2.9	5.9	8.8	1.8	4.7
43	.88	.75	.63	.51	.39	.27	.15	5.02	.90	2.7	5.4	8.0	50.7	3.4
44	.87	.75	.62	.50	.37	.24	.12	4.99	.86	2.4	4.8	7.2	49.7	2.1
29 45	26.87	53.74	80.61	107.48	134.35	161.21	188.08	214.95	241.82	1612.1	3224.3	4836.4	6448.6	8060.7
46	.87	.73	.59	.46	.33	.19	.05	.92	.78	1.9	3.8	5.6	7.5	59.4
47	.86	.72	.58	.44	.31	.16	8.02	.88	.74	1.6	3.2	4.8	6.5	8.1
48	.86	.71	.57	.43	.28	.13	7.99	.85	.70	1.3	2.7	4.1	5.4	6.7
49	.85	.70	.55	.41	.26	.11	.96	.81	.66	1.1	2.2	3.3	4.3	5.4
29 50	26.85	53.69	80.54	107.39	134.24	161.08	187.93	214.78	241.62	1610.8	3221.6	4832.5	6443.3	8054.1
51	.84	.68	.53	.37	.21	.05	.90	.74	.58	0.5	1.1	1.7	2.2	2.7
52	.84	.67	.51	.35	.19	.03	.87	.70	.54	0.3	0.6	0.9	1.1	1.4
53	.83	.67	.50	.34	.17	1.00	.84	.67	.50	10.0	20.0	30.0	40.1	50.1
54	.83	.66	.49	.32	.15	0.97	.81	.63	.46	09.7	19.5	29.2	39.0	48.7
29 55	26.82	53.65	80.47	107.30	134.12	160.95	187.77	214.60	241.42	1609.5	3219.0	4828.4	6437.9	8047.4
56	.82	.64	.46	.28	.10	.92	.74	.56	.38	9.2	8.4	7.6	6.8	6.0
57	.82	.63	.45	.26	.08	.89	.71	.53	.34	8.9	7.9	6.8	5.8	4.7
58	.81	.62	.43	.25	.06	.87	.68	.49	.30	8.7	7.4	6.0	4.7	3.4
59	.81	.61	.42	.23	.03	.84	.65	.45	.26	8.4	6.8	5.2	3.6	2.0
29 60	26.80	53.60	80.41	107.21	134.01	160.81	187.62	214.42	241.22	1608.1	3216.3	4824.4	6432.5	8040.7

Lat.	Latitude 29° to 30°—Meridional arcs. Value of 1″	Sums of seconds for middle latitude.		Value of 1″	Sums of minutes for middle latitude.		Latitude 29°—Co-ordinates of curvature. Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
29 00	30.787			1847.19					
1	7	1	30.79	.20	1	1 847.2	0 1	1 624.0	0.1
2	7	2	61.58	.20	2	3 694.4	2	3 248.0	0.5
3	7	3	92.37	.21	3	5 541.6	3	4 872.0	1.0
4	7	4	123.16	.21	4	7 388.8	4	6 496.1	1.8
29 05	30.787	5	153.94	1847.22	5	9 236.0	0 5	8 120.1	2.9
6	7	6	184.73	.22	6	11 083.2	6	9 744.1	4.1
7	7	7	215.52	.23	7	12 930.5	7	11 368.1	5.6
8	7	8	246.31	.23	8	14 777.7	8	12 992.1	7.3
9	7	9	277.10	.24	9	16 624.9	9	14 616.1	9.3
29 10	30.787	10	307.89	1847.24	10	18 472.2	0 10	16 240.1	11.5
11	7	1	338.68	.24	1	20 319.4	15	24 360.2	25.8
12	7	2	369.47	.25	2	22 166.7	20	32 480.2	45.8
13	8	3	400.26	.25	3	24 013.9	25	40 600.2	71.6
14	8	4	431.04	.26	4	25 861.2	30	48 720.3	103.1
29 15	30.788	15	461.83	1847.26	15	27 708.4	0 35	56 840.2	140.3
16	8	6	492.62	.27	6	29 555.7	40	64 960.2	183.2
17	8	7	523.41	.27	7	31 403.0	45	73 080.1	231.9
18	8	8	554.20	.28	8	33 250.2	50	81 200.0	286.3
19	8	9	584.99	.28	9	35 097.5	55	89 319.8	346.4
29 20	30.788	20	615.78	1847.29	20	36 944.8	1 00	97 439.6	412.2
21	8	1	646.57	.29	1	38 792.1	05	105 559.4	483.8
22	8	2	677.36	.30	2	40 639.4	10	113 679.1	561.1
23	8	3	708.14	.30	3	42 486.7	15	121 798.7	644.1
24	8	4	738.93	.31	4	44 334.0	20	129 918.3	732.9
29 25	30.788	25	769.72	1847.31	25	46 181.3	1 25	138 037.8	827.4
26	9	6	800.51	.31	6	48 028.6	30	146 157.3	927.6
27	9	7	831.30	.32	7	49 875.9	35	154 276.7	1 033.5
28	9	8	862.09	.32	8	51 723.2	40	162 396.0	1 145.1
29	9	9	892.88	.33	9	53 570.6	45	170 515.2	1 262.5
29 30	30.789	30	923.67	1847.33	30	55 417.9	1 50	178 634.3	1 385.6
31	9	1	954.46	.34	1	57 265.2	55	186 753.4	1 514.4
32	9	2	985.24	.34	2	59 112.6	2 00	194 872	1 649
33	9	3	1 016.03	.35	3	60 959.9	3 00	292 291	3 710
34	9	4	1 046.82	.35	4	62 807.3	4 00	389 689	6 595
29 35	30.789	35	1 077.61	1847.36	35	64 654.6	5 00	487 059	10 305
36	9	6	1 108.40	.36	6	66 502.0	6 00	584 394	14 838
37	9	7	1 139.19	.37	7	68 349.3	7 00	681 687	20 194
38	90	8	1 169.98	.37	8	70 196.7	8 00	778 931	26 374
39	0	9	1 200.77	.38	9	72 044.1	9 00	876 120	33 376
29 40	30.790	40	1 231.56	1847.38	40	73 891.5	10 00	973 246	41 199
41	0	1	1 262.34	.38	1	75 738.9	11 00	1 070 302	49 845
42	0	2	1 293.13	.39	2	77 586.2	12 00	1 167 282	59 313
43	0	3	1 323.92	.39	3	79 433.6	13 00	1 264 178	69 601
44	0	4	1 354.71	.40	4	81 281.0	14 00	1 360 983	80 706
29 45	30.790	45	1 385.50	1847.40	45	83 128.4	15 00	1 457 691	92 631
46	0	6	1 416.29	.41	6	84 975.8	16 00	1 554 295	105 375
47	0	7	1 447.08	.41	7	86 823.2	17 00	1 650 787	118 935
48	0	8	1 477.87	.42	8	88 670.7	18 00	1 747 161	133 311
49	0	9	1 508.66	.42	9	90 518.1	19 00	1 843 410	148 502
29 50	30.790	50	1 539.44	1847.43	50	92 365.5	20 00	1 939 527	164 506
51	1	1	1 570.23	.43	1	94 212.9	21 00	2 035 505	181 324
52	1	2	1 601.02	.44	2	96 060.4	22 00	2 131 338	198 953
53	1	3	1 631.81	.44	3	97 907.8	23 00	2 227 020	217 392
54	1	4	1 662.60	.45	4	99 755.3	24 00	2 322 539	236 640
29 55	30.791	55	1 693.39	1847.45	55	101 602.7	25 00	2 417 893	256 695
56	1	6	1 724.18	.46	6	103 450.2	26 00	2 513 074	277 558
57	1	7	1 754.97	.46	7	105 297.6	27 00	2 608 075	299 224
58	1	8	1 785.76	.46	8	107 145.1	28 00	2 702 890	321 694
59	1	9	1 816.54	.47	9	108 992.5	29 00	2 797 511	344 964
60	30.791	60	1 847.33	1847.47	60	110 840.0	30 00	2 891 931	369 036

Latitude 30° to 31°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
30 00	26.80	53.60	80.41	107.21	134.01	160.81	187.62	214.42	241.22	1608.1	3216.3	4824.4	6432.5	8040.7
1	.80	.59	.39	.19	3.99	.79	.59	.38	.18	7.9	5.7	3.6	1.4	39.3
2	.79	.58	.38	.17	.97	.76	.56	.35	.14	7.6	5.2	2.8	30.4	8.0
3	.79	.57	.37	.16	.94	.73	.52	.31	.10	7.3	4.6	2.0	29.3	6.6
4	.78	.56	.35	.14	.92	.71	.49	.28	.06	7.1	4.1	1.2	8.3	5.3
30 05	26.78	53.55	80.34	107.12	133.90	160.68	187.46	214.24	241.02	1606.8	3213.6	4820.4	6427.2	8033.9
6	.78	.55	.33	.10	.88	.65	.43	.20	0.98	6.5	3.0	19.6	6.1	2.6
7	.77	.54	.31	.08	.86	.62	.40	.17	.94	6.2	2.5	8.8	5.0	31.3
8	.77	.53	.30	.07	.83	.60	.36	.13	.90	6.0	2.0	7.9	4.0	29.9
9	.76	.52	.29	.05	.81	.57	.33	.10	.86	5.7	1.4	7.1	2.9	8.6
30 10	26.76	53.51	80.27	107.03	133.79	160.54	187.30	214.06	240.82	1605.4	3210.9	4816.3	6421.8	8027.2
11	.75	.50	.26	7.01	.77	.52	.27	4.02	.78	5.2	10.4	5.5	20.7	5.9
12	.75	.49	.24	6.99	.74	.49	.24	3.99	.74	4.9	09.8	4.7	19.6	4.5
13	.74	.48	.23	.98	.72	.46	.21	.95	.70	4.6	9.3	3.9	8.6	3.2
14	.74	.47	.22	.96	.70	.44	.18	.92	.65	4.4	8.7	3.1	7.5	1.8
30 15	26.73	53.46	80.20	106.94	133.68	160.41	187.14	213.88	240.61	1604.1	3208.2	4812.3	6416.4	8020.4
16	.73	.46	.19	.92	.65	.38	.11	.84	.57	3.8	7.6	1.5	5.3	19.1
17	.73	.45	.18	.90	.63	.35	.08	.81	.53	3.5	7.1	10.7	4.2	7.7
18	.72	.44	.16	.89	.61	.33	.05	.77	.49	3.3	6.6	09.8	3.1	6.4
19	.72	.43	.15	.87	.58	.30	7.02	.73	.45	3.0	6.0	9.0	2.0	5.0
30 20	26.71	53.42	80.14	106.85	133.56	160.27	186.99	213.70	240.41	1602.7	3205.5	4808.2	6410.9	8013.7
21	.71	.41	.12	.83	.54	.24	.96	.66	37	2.4	4.9	7.4	09.8	2.3
22	.70	.40	.11	.81	.52	.22	.93	.63	.33	2.2	4.4	6.6	8.7	11.0
23	.70	.39	.10	.80	.49	.19	.89	.59	.29	1.9	3.8	5.7	7.7	09.6
24	.69	.38	.08	.78	.47	.16	.86	.56	.25	1.6	3.3	4.9	6.6	8.2
30 25	26.69	53.37	80.07	106.76	133.45	160.14	186.83	213.52	240.21	1601.4	3202.8	4804.1	6405.5	8006.9
26	.69	.37	.06	.74	.43	.11	.80	.48	.16	1.1	2.2	3.3	4.4	5.5
27	.68	.36	.04	.72	.41	.08	.77	.45	.13	0.8	1.6	2.5	3.3	4.2
28	.68	.35	.03	.71	.38	.06	.73	.41	.08	0.6	1.1	1.6	2.3	2.8
29	.67	.34	.01	.69	.36	.03	.70	.38	.04	0.3	0.6	0.8	1.2	1.4
30.30	26.67	53.33	80.00	106.67	133.34	160.00	186.67	213.34	240.00	1600.0	3200.0	4800.0	6400.1	8000.1
31	.66	.32	79.99	.65	.32	59.97	.64	.30	39.96	599.7	199.5	799.2	399.0	7998.7
32	.66	.31	.97	.63	.29	.95	.61	.27	.92	9.5	8.9	8.4	7.9	7.3
33	.65	.30	.96	.62	.27	.92	.57	.23	.88	9.2	8.4	7.5	6.8	6.0
34	.65	.29	.95	.60	.25	.89	.54	.19	.84	8.9	7.8	6.7	5.7	4.6
30 35	26.65	53.29	79.93	106.58	133.22	159.86	186.51	213.15	239.80	1598.6	3197.3	4795.9	6394.6	7993.2
36	.64	.28	.92	.56	.20	.84	.48	.12	.76	8.4	6.8	5.1	3.5	1.9
37	.64	.27	.90	.54	.18	.81	.45	.08	.71	8.1	6.2	4.3	2.4	90.5
38	.63	.26	.89	.52	.16	.78	.41	.04	.67	7.8	5.7	3.4	1.3	89.1
39	.63	.25	.88	.51	.13	.76	.38	3.01	.63	7.6	5.1	2.6	90.2	7.8
30 40	26.62	53.24	79.86	106.49	133.11	159.73	186.35	212.97	239.59	1597.3	3194.6	4791.8	6389.1	7986.4
41	.62	.23	.85	.47	.09	.70	.32	.93	.55	7.0	4.0	1.0	8.0	5.0
42	.61	.22	.84	.45	.06	.67	.29	.90	.51	6.7	3.5	90.2	6.9	3.6
43	.61	.21	.82	.43	.04	.65	.25	.86	.47	6.5	2.9	89.3	5.8	2.3
44	.60	.20	.81	.41	.02	.62	.22	.82	.43	6.2	2.4	8.5	4.7	80.9
30 45	26.60	53.19	79.80	106.40	133.00	159.59	186.19	212.79	239.39	1595.9	3191.8	4787.7	6383.6	7979.5
46	.60	.19	.78	.38	2.97	.56	.16	.75	.35	5.6	1.3	6.9	2.5	8.2
47	.59	.18	.77	.36	.95	.53	.13	.71	.30	5.3	0.7	6.1	1.4	6.8
48	.59	.17	.75	.34	.93	.51	.09	.68	.26	5.1	90.2	5.2	80.3	5.4
49	.58	.16	.74	.32	.90	.48	.06	.64	.22	4.8	89.6	4.4	79.2	4.0
30 50	26.58	53.15	79.73	106.30	132.88	159.45	186.03	212.60	239.18	1594.5	3189.1	4783.6	6378.1	7972.7
51	.57	.14	.71	.28	.86	.42	6.00	.57	.14	4.2	8.5	2.8	7.0	71.3
52	.57	.13	.70	.26	.83	.40	5.97	.53	.10	4.0	8.0	2.0	5.9	69.9
53	.56	.12	.69	.25	.81	.37	.93	.49	.06	3.7	7.4	1.1	4.8	8.5
54	.56	.11	.67	.23	.79	.34	.90	.46	9.01	3.4	6.9	4780.3	3.7	7.1
30 55	26.55	53.10	79.66	106.21	132.76	159.32	185.87	212.42	238.97	1593.2	3186.3	4779.5	6372.6	7965.8
56	.55	.10	.64	.19	.74	.29	.84	.38	.93	2.9	5.8	8.7	1.5	4.4
57	.55	.09	.63	.17	.72	.26	.81	.35	.89	2.6	5.2	7.8	70.4	3.0
58	.54	.08	.62	.16	.70	.23	.77	.31	.85	2.3	4.6	7.0	69.3	1.6
59	.54	.07	.60	.14	.67	.21	.74	.27	.81	2.1	4.1	6.1	8.2	60.2
30 60	26.53	53.06	79.59	106.12	132.65	159.18	185.71	212.24	238.77	1591.8	3183.5	4775.3	6367.1	7958.9

Lat.	Latitude 30° to 31°—Meridional arcs.						Latitude 30°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
30 00	30.791			1847.47					
1	1	1	30.79	.48	1	1 847.5	0 1	1 608.1	0.1
2	1	2	61.59	.48	2	3 695.0	2	3 216.3	0.5
3	1	3	92.38	.49	3	5 542.4	3	4 824.4	1.1
4	2	4	123.17	.49	4	7 389.9	4	6 432.6	1.9
30 05	30.792	5	153.97	1847.50	5	9 237.4	0 5	8 040.7	2.9
6	2	6	184.76	.50	6	11 084.9	6	9 648.8	4.2
7	2	7	215.56	.51	7	12 932.4	7	11 257.0	5.7
8	2	8	246.35	.51	8	14 779.9	8	12 865.1	7.5
9	2	9	277.14	.52	9	16 627.4	9	14 473.2	9.5
30 10	30.792	10	307.94	1847.52	10	18 475.0	0 10	16 081.4	11.7
11	2	1	338.73	.53	1	20 322.5	15	24 122.0	26.3
12	2	2	369.52	.53	2	22 170.0	20	32 162.7	46.8
13	2	3	400.32	.54	3	24 017.5	25	40 203.3	73.1
14	2	4	431.11	.54	4	25 865.1	30	48 244.0	105.3
30 15	30.792	15	461.90	1847.55	15	27 712.6	0 35	56 284.6	143.3
16	3	6	492.70	.55	6	29 560.2	40	64 325.1	187.1
17	3	7	523.49	.56	7	31 407.7	45	72 365.6	236.8
18	3	8	554.29	.56	8	33 255.3	50	80 406.1	292.4
19	3	9	585.08	.56	9	35 102.8	55	88 446.6	353.8
30 20	30.793	20	615.87	1847.57	20	36 950.4	1 00	96 487.0	421.0
21	3	1	646.67	.57	1	38 798.0	05	104 527.3	494.1
22	3	2	677.46	.58	2	40 645.5	10	112 567.6	573.0
23	3	3	708.25	.58	3	42 493.1	15	120 607.9	657.8
24	3	4	739.05	.59	4	44 340.7	20	128 648.0	748.4
30 25	30.793	25	769.84	1847.59	25	46 188.3	1 25	136 688.1	844.9
26	3	6	800.63	.60	6	48 035.9	30	144 728.2	947.3
27	3	7	831.43	.60	7	49 883.5	35	152 768.2	1 055.4
28	3	8	862.22	.61	8	51 731.1	40	160 808.0	1 169.4
29	4	9	893.01	.61	9	53 578.7	45	168 847.8	1 289.3
30 30	30.794	30	923.81	1847.62	30	55 426.3	1 50	176 887.5	1 415.0
31	4	1	954.60	.62	1	57 273.9	55	184 927.1	1 546.6
32	4	2	985.40	.63	2	59 121.6	2 00	192 967	1 684
33	4	3	1 016.19	.63	3	60 969.2	3 00	289 432	3 789
34	4	4	1 046.98	.64	4	62 816.8	4 00	385 875	6 735
30 35	30.794	35	1 077.78	1847.64	35	64 664.5	5 00	482 288	10 523
36	4	6	1 108.57	.65	6	66 512.1	6 00	578 665	15 153
37	4	7	1 139.36	.65	7	68 359.8	7 00	674 998	20 623
38	4	8	1 170.16	.66	8	70 207.4	8 00	771 279	26 934
39	4	9	1 200.95	.66	9	72 055.1	9 00	867 502	34 084
30 40	30.794	40	1 231.74	1847.66	40	73 902.7	10 00	963 658	42 074
41	4	1	1 262.54	.67	1	75 750.4	11 00	1 059 741	50 903
42	5	2	1 293.33	.67	2	77 598.1	12 00	1 155 744	60 570
43	5	3	1 324.13	.68	3	79 445.8	13 00	1 251 658	71 074
44	5	4	1 354.92	.68	4	81 293.4	14 00	1 347 477	82 415
30 45	30.795	45	1 385.71	1847.69	45	83 141.1	15 00	1 443 193	94 591
46	5	6	1 416.51	.69	6	84 988.8	16 00	1 538 800	107 603
47	5	7	1 447.30	.70	7	86 836.5	17 00	1 634 290	121 449
48	5	8	1 478.09	.70	8	88 684.2	18 00	1 729 654	136 127
49	5	9	1 508.89	.71	9	90 531.9	19 00	1 824 887	151 637
30 50	30.795	50	1 539.68	1847.71	50	92 379.6	20 00	1 919 982	167 977
51	5	1	1 570.47	.72	1	94 227.4	21 00	2 014 930	185 147
52	5	2	1 601.27	.72	2	96 075.1	22 00	2 109 725	203 143
53	5	3	1 632.06	.73	3	97 922.8	23 00	2 204 359	221 966
54	6	4	1 662.86	.73	4	99 770.5	24 00	2 298 825	241 616
30 55	30.796	55	1 693.65	1847.74	55	101 618.3	25 00	2 393 116	262 089
56	6	6	1 724.44	.74	6	103 466.0	26 00	2 487 224	283 383
57	6	7	1 755.24	.75	7	105 313.7	27 00	2 581 144	305 498
58	6	8	1 786.03	.75	8	107 161.5	28 00	2 674 867	328 432
59	6	9	1 816.82	.76	9	109 009.2	29 00	2 768 385	352 183
30 60	30.796	60	1 847.62	.76	60	110 857.0	30 00	2 861 694	376 749

Latitude 31° to 32°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
31 00	26.53	53.06	79.59	106.12	132.65	159.18	185.71	212.24	238.77	1591.8	3183.5	4775.3	6367.1	7958.9
1	.53	.05	.58	.10	.63	.15	.68	.20	.73	1.5	3.0	4.5	6.0	7.5
2	.52	.04	.56	.08	.60	.12	.64	.16	.68	1.2	2.4	3.6	4.9	6.1
3	.52	.03	.55	.06	.58	.09	.61	.13	.64	0.9	1.9	2.8	3.8	4.7
4	.51	.02	.53	.04	.56	.07	.58	.09	.60	0.7	1.3	1.9	2.6	3.3
31 05	26.51	53.02	79.52	106.03	132.53	159.04	185.55	212.05	238.56	1590.4	3180.8	4771.1	6361.5	7951.9
6	.50	.01	.51	6.01	.51	9.01	.51	2.01	.52	90.1	80.2	70.3	60.4	50.5
7	.50	3.00	.49	5.99	.49	8.98	.48	1.98	.48	89.8	79.7	69.5	59.3	49.1
8	.49	2.99	.48	.97	.47	.96	.45	.94	.43	9.6	9.1	8.6	8.2	7.8
9	.49	.98	.46	.95	.44	.93	.41	.90	.39	9.3	8.6	7.8	7.1	6.4
31 10	26.48	52.97	79.45	105.93	132.42	158.90	185.38	211.87	238.35	1589.0	3178.0	4767.0	6356.0	7945.0
11	.48	.96	.44	.91	.39	.87	.35	.83	.31	8.7	7.4	6.2	4.9	3.6
12	.47	.95	.42	.90	.37	.84	.32	.79	.27	8.4	6.9	5.3	3.8	2.2
13	.47	.94	.41	.88	.35	.82	.28	.75	.22	8.2	6.3	4.5	2.6	40.8
14	.46	.93	.39	.86	.32	.79	.25	.72	.18	7.9	5.8	3.6	1.5	39.4
31 15	26.46	52.92	79.38	105.84	132.30	158.76	185.22	211.68	238.14	1587.6	3175.2	4762.8	6350.4	7938.0
16	.46	.91	.37	.82	.28	.73	.19	.64	.10	7.3	4.6	2.0	49.3	6.6
17	.45	.90	.35	.80	.25	.70	.16	.61	.06	7.0	4.1	1.1	8.2	5.2
18	.45	.89	.34	.78	.23	.68	.12	.57	8.01	6.8	3.5	60.3	7.1	3.8
19	.44	.88	.32	.77	.21	.65	.09	.53	7.97	6.5	3.0	59.4	5.9	2.4
31 20	26.44	52.87	79.31	105.75	132.18	158.62	185.06	211.49	237.93	1586.2	3172.4	4758.6	6344.8	7931.0
21	.43	.86	.30	.73	.16	.59	5.03	.46	.89	5.9	1.8	7.8	3.7	29.6
22	.43	.85	.28	.71	.13	.56	4.99	.42	.85	5.6	1.3	6.9	2.6	8.2
23	.42	.84	.27	.69	.11	.54	.96	.38	.80	5.4	0.7	6.1	1.5	6.8
24	.42	.83	.25	.67	.09	.51	.93	.34	.76	5.1	70.2	5.2	40.3	5.4
31 25	26.41	52.83	79.24	105.65	132.06	158.48	184.89	211.31	237.72	1584.8	3169.6	4754.4	6339.2	7924.0
26	.41	.82	.23	.63	.04	.45	.86	.27	.68	4.5	9.0	3.6	8.1	2.6
27	.40	.81	.21	.62	.02	.42	.83	.23	.64	4.2	8.5	2.7	7.0	21.2
28	.40	.80	.20	.60	2.00	.40	.80	.20	.59	4.0	7.9	1.9	5.9	19.8
29	.39	.79	.18	.58	1.97	.37	.76	.16	.55	3.7	7.4	1.0	4.7	8.4
31 30	26.39	52.78	79.17	105.56	131.95	158.34	184.73	211.12	237.51	1583.4	3166.8	4750.2	6333.6	7917.0
31	.39	.77	.16	.54	.93	.31	.70	.08	.47	3.1	6.2	49.4	2.5	5.6
32	.38	.76	.14	.52	.90	.28	.66	.05	.43	2.8	5.7	8.5	1.4	4.2
33	.38	.75	.13	.50	.88	.26	.63	1.01	.38	2.6	5.1	7.7	30.2	2.8
34	.37	.74	.11	.49	.86	.23	.60	0.97	.34	2.3	4.6	6.8	29.1	1.4
31 35	26.37	52.74	79.10	105.47	131.84	158.20	184.56	210.93	237.30	1582.0	3164.0	4746.0	6328.0	7910.0
36	.36	.73	.09	.45	.81	.17	.53	.90	.26	1.7	3.4	5.2	6.9	08.6
37	.36	.72	.07	.43	.79	.14	.50	.86	.22	1.4	2.9	4.3	5.7	7.2
38	.35	.71	.06	.41	.77	.12	.47	.82	.17	1.2	2.3	3.5	4.6	5.8
39	.35	.70	.04	.39	.74	.09	.43	.78	.13	0.9	1.8	2.6	3.5	4.4
31 40	26.34	52.69	79.03	105.37	131.72	158.06	184.40	210.75	237.09	1580.6	3161.2	4741.8	6322.4	7903.0
41	.34	.68	.02	.35	.69	.03	.37	.71	.05	0.3	0.6	0.9	1.2	1.5
42	.33	.67	9.00	.33	.67	8.00	.33	.67	7.00	80.0	60.0	40.1	20.1	900.1
43	.33	.66	8.99	.32	.65	7.98	.30	.63	6.96	79.8	59.5	39.2	19.0	898.7
44	.32	.65	.97	.30	.62	.95	.27	.59	.92	9.5	8.9	8.4	7.8	7.3
31 45	26.32	52.64	78.96	105.28	131.60	157.92	184.24	210.56	236.87	1579.2	3158.3	4737.5	6316.7	7895.9
46	.32	.63	.95	.26	.58	.89	.20	.52	.83	8.9	7.8	6.7	5.6	4.5
47	.31	.62	.93	.24	.55	.86	.17	.48	.79	8.6	7.2	5.8	4.4	3.0
48	.31	.61	.92	.22	.53	.84	.14	.44	.75	8.4	6.6	5.0	3.3	1.6
49	.30	.60	.90	.20	.50	.80	.11	.41	.70	8.0	6.1	4.1	2.2	90.2
31 50	26.30	52.59	78.89	105.18	131.48	157.78	184.07	210.37	236.66	1577.8	3155.5	4733.3	6311.0	7888.8
51	.29	.58	.87	.16	.46	.75	.04	.33	.62	7.5	4.9	2.4	09.9	7.4
52	.29	.57	.86	.15	.43	.72	4.00	.29	.58	7.2	4.4	1.6	8.8	6.0
53	.28	.56	.85	.13	.41	.69	3.97	.25	.53	6.9	3.8	30.7	7.6	4.5
54	.28	.55	.83	.11	.38	.66	.94	.22	.49	6.6	3.3	29.9	6.5	83.1
31 55	26.27	52.55	78.82	105.09	131.36	157.63	183.90	210.18	236.45	1576.3	3152.7	4729.0	6305.4	7881.7
56	.27	.54	.80	.07	.34	.61	.87	.14	.41	6.1	2.1	8.2	4.2	80.3
57	.26	.53	.79	.05	.31	.58	.84	.10	.37	5.8	1.5	7.3	3.1	78.9
58	.26	.52	.77	.03	.29	.55	.81	.07	.32	5.5	1.0	6.5	2.0	7.4
59	.25	.51	.76	5.01	.26	.52	.77	10.03	.28	5.2	50.4	5.6	300.8	6.0
31 60	26.25	52.50	78.75	104.99	131.24	157.49	183.74	209.99	236.24	1574.9	3149.8	4724.8	6299.7	7874.6

Lat.	Latitude 31° to 32°—Meridional arcs.						Latitude 31°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
31 00	30.796			1847.76					
1	6	1	30.80	.77	1	1 847.8	0 1	1 591.8	0.1
2	6	2	61.60	.77	2	3 695.5	2	3 183.5	0.5
3	6	3	92.40	.78	3	5 543.3	3	4 775.3	1.1
4	6	4	123.19	.78	4	7 391.1	4	6 367.1	1.9
31 05	30.796	5	153.99	1847.79	5	9 238.9	0 5	7 958.9	3.0
6	7	6	184.79	.79	6	11 086.7	6	9 550.6	4.3
7	7	7	215.59	.80	7	12 934.4	7	11 142.4	5.8
8	7	8	246.39	.80	8	14 782.2	8	12 734.2	7.6
9	7	9	277.19	.80	9	16 630.0	9	14 325.9	9.7
31 10	30.797	10	307.98	1847.81	10	18 477.9	0 10	15 917.7	11.9
11	7	1	338.78	.81	1	20 325.7	15	23 876.5	26.8
12	7	2	369.58	.82	2	22 173.5	20	31 835.4	47.7
13	7	3	400.38	.82	3	24 021.3	25	39 794.2	74.5
14	7	4	431.18	.83	4	25 869.1	30	47 753.0	107.3
31 15	30.797	15	461.98	1847.83	15	27 717.0	0 35	55 711.7	146.1
16	7	6	492.78	.84	6	29 564.8	40	63 670.4	190.8
17	7	7	523.57	.84	7	31 412.6	45	71 629.2	241.5
18	7	8	554.37	.85	8	33 260.5	50	79 587.8	298.1
19	8	9	585.17	.85	9	35 108.3	55	87 546.4	360.7
31 20	30.798	20	615.97	1847.86	20	36 956.2	1 00	95 505.0	429.3
21	8	1	646.77	.86	1	38 804.0	05	103 463.5	503.8
22	8	2	677.57	.87	2	40 651.9	10	111 421.9	584.3
23	8	3	708.36	.87	3	42 499.8	15	119 380.3	670.7
24	8	4	739.16	.88	4	44 347.7	20	127 338.6	763.1
31 25	30.798	25	769.96	1847.88	25	46 195.5	1 25	135 296.9	861.5
26	8	6	800.76	.89	6	48 043.4	30	143 255.1	965.8
27	8	7	831.56	.89	7	49 891.3	35	151 213.1	1 076.1
28	8	8	862.36	.90	8	51 739.2	40	159 171.1	1 192.4
29	8	9	893.15	.90	9	53 587.1	45	167 129.0	1 314.6
31 30	30.798	30	923.95	1847.91	30	55 435.0	1 50	175 086.8	1 442.8
31	9	1	954.75	.91	1	57 282.9	55	183 044.6	1 576.9
32	9	2	985.55	.92	2	59 130.8	2 00	191 002	1 717
33	9	3	1 016.35	.92	3	60 978.8	3 00	286 484	3 863
34	9	4	1 047.15	.93	4	62 826.7	4 00	381 943	6 867
31 35	30.799	35	1 077.95	1847.93	35	64 674.6	5 00	477 371	10 729
36	9	6	1 108.74	.94	6	66 522.5	6 00	572 760	15 450
37	9	7	1 139.54	.94	7	68 370.5	7 00	668 103	21 027
38	9	8	1 170.34	.95	8	70 218.4	8 00	763 392	27 461
39	9	9	1 201.14	.95	9	72 066.4	9 00	858 619	34 751
31 40	30.799	40	1 231.94	1847.96	40	73 914.3	10 00	953 777	42 897
41	9	1	1 262.74	.96	1	75 762.3	11 00	1 048 858	51 898
42	799	2	1 293.53	.97	2	77 610.2	12 00	1 143 854	61 753
43	800	3	1 324.33	.97	3	79 458.2	13 00	1 238 758	72 462
44	0	4	1 355.13	.98	4	81 306.2	14 00	1 333 561	84 024
31 45	30.800	45	1 385.93	1847.98	45	83 154.2	15 00	1 428 257	96 437
46	0	6	1 416.73	.98	6	85 002.1	16 00	1 522 837	109 701
47	0	7	1 447.53	.99	7	86 850.1	17 00	1 617 294	123 815
48	0	8	1 478.33	7.99	8	88 698.1	18 00	1 711 621	138 777
49	0	9	1 509.12	1848.00	9	90 546.1	19 00	1 805 810	154 586
31 50	30.800	50	1 539.92	1848.00	50	92 394.1	20 00	1 899 852	171 241
51	0	1	1 570.72	.01	1	94 242.1	21 00	1 993 740	188 741
52	0	2	1 601.52	.01	2	96 090.1	22 00	2 087 468	207 085
53	0	3	1 632.32	.02	3	97 938.2	23 00	2 181 027	226 270
54	0	4	1 663.12	.02	4	99 786.2	24 00	2 274 411	246 295
31 55	30.800	55	1 693.91	1848.03	55	101 634.2	25 00	2 367 610	267 159
56	1	6	1 724.71	.03	6	103 482.2	26 00	2 460 618	288 860
57	1	7	1 755.51	.04	7	105 330.3	27 00	2 553 427	311 396
58	1	8	1 786.31	.04	8	107 178.3	28 00	2 646 029	334 765
59	1	9	1 817.11	.05	9	109 026.4	29 00	2 738 418	358 966
31 60	30.801	60	1 847.91	1848.05	60	110 874.4	30 00	2 830 585	383 997

Latitude 32° to 33°—Arcs of the Parallel in meters.

Lat. ° ′	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
32 00	26.25	52.50	78.75	104.99	131.24	157.49	183.74	209.99	236.24	1574.9	3149.8	4724.8	6299.7	7874.6
1	.24	.49	.73	.98	.22	.46	.71	.95	.20	4.6	9.3	3.9	8.5	3.2
2	.24	.48	.72	.96	.19	.43	.67	.91	.15	4.3	8.7	3.1	7.4	1.7
3	.23	.47	.70	.94	.17	.41	.64	.87	.11	4.1	8.1	2.2	6.2	70.3
4	.23	.46	.69	.92	.15	.38	.61	.84	.07	3.8	7.6	1.4	5.1	68.9
32 05	26.22	52.45	78.67	104.90	131.12	157.35	183.57	209.80	236.02	1573.5	3147.0	4720.5	6294.0	7867.4
6	.22	.44	.66	.88	.10	.32	.54	.76	5.98	3.2	6.4	19.6	2.8	6.0
7	.22	.43	.65	.86	.08	.29	.51	.72	.94	2.9	5.8	8.8	1.7	4.6
8	.21	.42	.63	.84	.06	.26	.48	.68	.90	2.6	5.3	7.9	90.5	3.2
9	.21	.41	.62	.82	.03	.23	.44	.65	.85	2.3	4.7	7.1	89.4	1.7
32 10	26.20	52.40	78.60	104.80	131.01	157.21	183.41	209.61	235.81	1572.1	3144.1	4716.2	6288.3	7860.3
11	.20	.39	.59	.79	0.99	.18	.38	.57	.77	1.8	3.6	5.3	7.1	58.9
12	.19	.38	.57	.77	.96	.15	.34	.53	.72	1.5	3.0	4.5	6.0	7.4
13	.19	.37	.56	.75	.94	.12	.31	.49	.68	1.2	2.4	3.6	4.8	6.0
14	.18	.36	.55	.73	.91	.09	.27	.46	.64	0.9	1.9	2.8	3.7	4.6
32 15	26.18	52.35	78.53	104.71	130.89	157.06	183.24	209.42	235.59	1570.6	3141.3	4711.9	6282.5	7853.1
16	.17	.34	.52	.69	.87	.03	.21	.38	.55	0.3	0.7	1.0	1.4	1.7
17	.17	.34	.50	.67	.84	7.01	.17	.34	.51	70.1	40.1	10.2	80.2	50.3
18	.16	.33	.49	.65	.82	6.98	.14	.30	.47	69.8	39.5	09.3	79.1	48.8
19	.16	.32	.47	.63	.79	.95	.10	.26	.42	9.5	9.0	8.5	7.9	7.4
32 20	26.15	52.31	78.46	104.61	130.77	156.92	183.07	209.23	235.38	1569.2	3138.4	4707.6	6276.8	7846.0
21	.15	.30	.45	.59	.75	.89	.04	.19	.34	8.9	7.8	6.7	5.6	4.5
22	.14	.29	.43	.57	.72	.86	3.00	.15	.29	8.6	7.2	5.9	4.5	3.1
23	.14	.28	.42	.56	.70	.83	2.97	.11	.25	8.3	6.7	5.0	3.3	1.6
24	.13	.27	.40	.54	.67	.80	.94	.07	.21	8.0	6.1	4.1	2.2	40.2
32 25	26.13	52.26	78.39	104.52	130.65	156.78	182.90	209.03	235.16	1567.8	3135.5	4703.3	6271.0	7838.8
26	.12	.25	.37	.50	.63	.75	.87	9.00	.12	7.5	4.9	2.4	69.9	7.3
27	.12	.24	.36	.48	.60	.72	.84	8.96	.08	7.2	4.3	1.5	68.7	5.9
28	.11	.23	.34	.46	.58	.69	.81	.92	5.04	6.9	3.8	700.7	7.6	4.4
29	.11	.22	.33	.44	.55	.66	.77	.88	4.99	6.6	3.2	699.8	6.4	3.0
32 30	26.11	52.21	78.32	104.42	130.53	156.63	182.74	208.84	234.95	1566.3	3132.6	4698.9	6265.3	7831.6
31	.10	.20	.30	.40	.51	.60	.70	.80	.90	6.0	2.0	8.0	4.1	30.1
32	.10	.19	.29	.38	.48	.57	.67	.76	.86	5.7	1.5	7.2	2.9	28.7
33	.09	.18	.27	.36	.45	.54	.64	.73	.82	5.4	0.9	6.3	1.8	7.2
34	.09	.17	.26	.34	.43	.52	.60	.69	.77	5.2	30.3	5.5	60.6	5.8
32 35	26.08	52.16	78.24	104.32	130.41	156.49	182.57	208.65	234.73	1564.9	3129.7	4694.6	6259.5	7824.3
36	.08	.15	.23	.30	.39	.46	.54	.61	.69	4.6	9.1	3.7	8.3	2.9
37	.07	.14	.21	.29	.36	.43	.50	.57	.64	4.3	8.6	2.9	7.1	1.4
38	.07	.13	.20	.27	.34	.40	.47	.53	.60	4.0	8.0	2.0	6.0	20.0
39	.06	.12	.18	.25	.31	.37	.43	.49	.55	3.7	7.4	1.1	4.8	18.5
32 40	26.06	52.11	78.17	104.23	130.29	156.34	182.40	208.46	234.51	1563.4	3126.8	4690.3	6253.7	7817.1
41	.05	.10	.16	.21	.26	.31	.37	.42	.47	3.1	6.2	89.4	2.5	5.6
42	.05	.09	.14	.19	.24	.28	.33	.38	.42	2.8	5.7	8.5	1.3	4.2
43	.04	.08	.13	.17	.22	.25	.30	.34	.38	2.5	5.1	7.7	50.2	2.7
44	.04	.08	.11	.15	.19	.23	.26	.30	.34	2.3	4.5	6.8	49.0	11.3
32 45	26.03	52.07	78.10	104.13	130.17	156.20	182.23	208.26	234.29	1562.0	3123.9	4685.9	6247.9	7809.8
46	.03	.06	.08	.11	.14	.17	.20	.22	.25	1.7	3.3	5.0	6.7	8.4
47	.02	.05	.07	.09	.12	.14	.16	.18	.21	1.4	2.7	4.1	5.5	6.9
48	.02	.04	.05	.07	.09	.11	.13	.15	.17	1.1	2.2	3.3	4.4	5.4
49	.01	.03	.04	.05	.07	.08	.09	.11	.12	0.8	1.6	2.4	3.2	4.0
32 50	26.01	52.02	78.03	104.03	130.04	156.05	182.06	208.07	234.08	1560.5	3121.0	4681.5	6242.0	7802.5
51	.00	.01	.01	4.01	30.02	6.02	2.03	8.03	4.03	60.2	20.4	80.6	40.9	801.1
52	6.00	2.00	8.00	3.99	29.99	5.99	1.99	7.99	3.99	59.9	19.8	79.7	39.7	799.6
53	5.99	1.99	7.98	.98	.97	.96	.96	.95	.95	9.6	9.3	8.9	8.5	8.2
54	.99	.98	.97	.96	.94	.93	.92	.91	.90	9.3	8.7	8.0	7.4	6.7
32 55	25.98	51.97	77.95	103.94	129.92	155.90	181.89	207.87	233.86	1559.0	3118.1	4677.1	6236.2	7795.2
56	.98	.96	.94	.92	.90	.88	.86	.83	.81	8.8	7.5	6.2	5.0	3.8
57	.97	.95	.92	.90	.87	.85	.82	.79	.77	8.5	6.9	5.4	3.8	2.3
58	.97	.94	.91	.88	.85	.82	.79	.76	.73	8.2	6.4	4.5	2.7	90.9
59	.96	.93	.89	.86	.82	.79	.75	.72	.68	7.9	5.8	3.7	1.5	89.4
32 60	25.96	51.92	77.88	103.84	129.80	155.76	181.72	207.68	233.64	1557.6	3115.2	4672.8	6230.3	7787.9

Lat.		Latitude 32° to 33°—Meridional arcs.						Latitude 32°—Co-ordinates of curvature.		
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
32	00	30.801			1848.05					
	1	1	1	30.80	.06	1	1 848.1	0 1	1 574.9	0.1
	2	1	2	61.61	.06	2	3 696.1	2	3 149.8	0.5
	3	1	3	92.41	.07	3	5 544.2	3	4 724.8	1.1
	4	1	4	123.21	.07	4	7 392.3	4	6 299.7	1.9
32	05	30.801	5	154.02	1848.08	5	9 240.3	0 5	7 874.6	3.0
	6	1	6	184.82	.08	6	11 088.4	6	9 449.5	4.4
	7	1	7	215.62	.09	7	12 936.5	7	11 024.4	6.0
	8	2	8	246.43	.09	8	14 784.6	8	12 599.4	7.8
	9	2	9	277.23	.10	9	16 632.7	9	14 174.3	9.8
32	10	30.802	10	308.03	1848.10	10	18 480.8	0 10	15 749.2	12.1
	11	2	1	338.84	.11	1	20 328.9	15	23 623.8	27.3
	12	2	2	369.64	.11	2	22 177.0	20	31 498.3	48.6
	13	2	3	400.44	.12	3	24 025.1	25	39 372.9	75.9
	14	2	4	431.25	.12	4	25 873.2	30	47 247.4	109.3
32	15	30.802	15	462.05	1848.13	15	27 721.4	0 35	55 121.9	148.7
	16	2	6	492.85	.13	6	29 569.5	40	62 996.4	194.2
	17	2	7	523.66	.14	7	31 417.6	45	70 870.8	245.8
	18	2	8	554.46	.14	8	33 265.8	50	78 745.2	303.5
	19	2	9	585.26	.15	9	35 113.9	55	86 619.5	367.2
32	20	30.803	20	616.07	1848.15	20	36 962.1	1 00	94 493.8	437.0
	21	3	1	646.87	.16	1	38 810.2	05	102 368.0	512.8
	22	3	2	677.67	.16	2	40 658.4	10	110 242.2	594.8
	23	3	3	708.48	.17	3	42 506.6	15	118 116.3	682.8
	24	3	4	739.28	.17	4	44 354.7	20	125 990.3	776.9
32	25	30.803	25	770.08	1848.18	25	46 202.9	1 25	133 864.3	877.0
	26	3	6	800.89	.18	6	48 051.1	30	141 738.2	983.2
	27	3	7	831.69	.19	7	49 899.3	35	149 612.0	1 095.5
	28	3	8	862.49	.19	8	51 747.5	40	157 485.7	1 213.8
	29	3	9	893.30	.20	9	53 595.6	45	165 359.3	1 338.2
32	30	30.803	30	924.10	1848.20	30	55 443.8	1 50	173 232.8	1 468.7
	31	3	1	954.90	.21	1	57 292.0	55	181 106.2	1 605.3
	32	4	2	985.71	.21	2	59 140.3	2 00	188 980	1 748
	33	4	3	1 016.51	.22	3	60 988.5	3 00	283 449	3 933
	34	4	4	1 047.31	.22	4	62 836.7	4 00	377 894	6 991
32	35	30.804	35	1 078.12	1848.23	35	64 684.9	5 00	472 307	10 922
	36	4	6	1 108.92	.23	6	66 533.1	6 00	566 680	15 727
	37	4	7	1 139.72	.24	7	68 381.4	7 00	661 004	21 404
	38	4	8	1 170.53	.24	8	70 229.6	8 00	755 272	27 954
	39	4	9	1 201.33	.25	9	72 077.8	9 00	849 475	35 375
32	40	30.804	40	1 232.13	1848.25	40	73 926.1	10 00	943 605	43 667
	41	4	1	1 262.94	.26	1	75 774.4	11 00	1 037 655	52 829
	42	4	2	1 293.74	.26	2	77 622.6	12 00	1 131 616	62 861
	43	4	3	1 324.54	.27	3	79 470.9	13 00	1 225 480	73 761
	44	5	4	1 355.35	.27	4	81 319.1	14 00	1 319 239	85 529
32	45	30.805	45	1 386.15	1848.28	45	83 167.4	15 00	1 412 885	98 164
	46	5	6	1 416.95	.28	6	85 015.7	16 00	1 506 411	111 664
	47	5	7	1 447.76	.29	7	86 864.0	17 00	1 599 808	126 029
	48	5	8	1 478.56	.29	8	88 712.3	18 00	1 693 067	141 256
	49	5	9	1 509.36	.30	9	90 560.5	19 00	1 786 182	157 346
32	50	30.805	50	1 540.17	1848.30	50	92 408.8	20 00	1 879 144	174 296
	51	5	1	1 570.97	.31	1	94 257.1	21 00	1 971 946	192 105
	52	5	2	1 601.77	.31	2	96 105.5	22 00	2 064 579	210 772
	53	5	3	1 632.58	.32	3	97 953.8	23 00	2 157 035	230 295
	54	5	4	1 663.38	.32	4	99 802.1	24 00	2 249 305	250 672
32	55	30.805	55	1 694.18	1848.33	55	101 650.4	25 00	2 341 385	271 901
	56	6	6	1 724.99	.33	6	103 498.7	26 00	2 433 264	293 981
	57	6	7	1 755.79	.34	7	105 347.1	27 00	2 524 935	316 910
	58	6	8	1 786.59	.34	8	107 195.4	28 00	2 616 390	340 686
	59	6	9	1 817.40	.35	9	109 043.8	29 00	2 707 621	365 307
32	60	30.806	60	1 848.20	1848.35	60	110 892.1	30 00	2 798 621	390 770

Latitude 33° to 34°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
33 00	25.96	51.92	77.88	103.84	129.80	155.76	181.72	207.68	233.64	1557.6	3115.2	4672.8	6230.3	7787.9
1	.96	.91	.87	.82	.78	.73	.69	.64	.60	7.3	4.6	1.9	29.2	6.5
2	.95	.90	.85	.80	.75	.70	.65	.60	.55	7.0	4.0	1.0	8.0	5.0
3	.95	.89	.84	.78	.73	.67	.62	.56	.51	6.7	3.4	70.1	6.8	3.5
4	.94	.88	.82	.76	.70	.64	.58	.52	.46	6.4	2.8	69.3	5.6	2.1
33 05	25.94	51.87	77.81	103.74	129.68	155.61	181.55	207.48	233.42	1556.1	3112.2	4668.4	6224.5	7780.6
6	.93	.86	.79	.72	.65	.58	.51	.44	.38	5.8	1.6	7.5	3.3	79.1
7	.93	.85	.78	.70	.63	.55	.48	.40	.33	5.5	1.1	6.6	2.1	7.7
8	.92	.84	.76	.68	.60	.53	.45	.37	.29	5.3	10.5	5.7	21.0	6.2
9	.92	.83	.75	.66	.58	.50	.41	.33	.24	5.0	09.9	4.8	19.8	4.7
33 10	25.91	51.82	77.73	103.64	129.55	155.47	181.38	207.29	233.20	1554.7	3109.3	4664.0	6218.6	7773.3
11	.91	.81	.72	.62	.53	.44	.35	.25	.16	4.4	8.7	3.1	7.4	1.8
12	.90	.80	.70	.60	.50	.41	.31	.21	.11	4.1	8.1	2.2	6.2	70.3
13	.90	.79	.69	.58	.48	.38	.28	.17	.07	3.8	7.5	1.3	5.1	68.8
14	.89	.78	.67	.57	.46	.35	.24	.13	3.02	3.5	7.0	60.4	3.9	7.4
33 15	25.89	51.77	77.66	103.55	129.43	155.32	181.21	207.09	232.98	1553.2	3106.4	4659.5	6212.7	7765.9
16	.88	.76	.64	.53	.41	.29	.17	.05	.93	2.9	5.8	8.6	1.5	4.4
17	.88	.75	.63	.51	.38	.26	.14	7.01	.89	2.6	5.2	7.7	10.4	2.9
18	.87	.74	.62	.49	.36	.23	.10	6.97	.85	2.3	4.6	6.9	09.2	1.5
19	.87	.73	.60	.47	.33	.20	.07	.93	.80	2.0	4.0	6.0	8.0	60.0
33 20	25.86	51.72	77.59	103.45	129.31	155.17	181.03	206.89	232.76	1551.7	3103.4	4655.1	6206.8	7758.5
21	.86	.71	.57	.43	.29	.14	1.00	.85	.71	1.4	2.8	4.2	5.6	7.0
22	.85	.70	.56	.41	.26	.11	0.96	.81	.67	1.1	2.2	3.3	4.4	5.6
23	.85	.69	.54	.39	.24	.08	.93	.78	.63	0.8	1.6	2.5	3.3	4.1
24	.84	.68	.53	.37	.21	.05	.89	.74	.58	0.5	1.0	1.6	2.1	2.6
33 25	25.84	51.67	77.51	103.35	129.19	155.02	180.86	206.70	232.54	1550.2	3100.4	4650.7	6200.9	7751.1
26	.83	.66	.50	.33	.16	4.99	.82	.66	.49	49.9	099.8	49.8	199.7	49.6
27	.83	.65	.48	.31	.14	.96	.79	.62	.45	9.6	9.3	8.9	8.5	8.2
28	.82	.64	.47	.29	.11	.93	.76	.58	.40	9.3	8.7	8.0	7.3	6.7
29	.82	.63	.45	.27	.09	.90	.72	.54	.36	9.0	8.1	7.1	6.2	5.2
33 30	25.81	51.62	77.44	103.25	129.06	154.87	180.69	206.50	232.31	1548.7	3097.5	4646.2	6195.0	7743.7
31	.81	.61	.42	.23	.04	.84	.65	.46	.27	8.4	6.9	5.3	3.8	2.2
32	.80	.60	.41	.21	9.01	.81	.62	.42	.22	8.1	6.3	4.4	2.6	40.7
33	.80	.59	.39	.19	8.99	.78	.58	.38	.18	7.8	5.7	3.5	1.4	39.2
34	.79	.59	.38	.17	.96	.76	.55	.34	.13	7.6	5.1	2.7	90.2	7.8
33 35	25.79	51.58	77.36	103.15	128.94	154.73	180.52	206.30	232.09	1547.3	3094.5	4641.8	6189.0	7736.3
36	.78	.57	.35	.13	.91	.70	.48	.26	.05	7.0	3.9	0.9	7.8	4.8
37	.78	.56	.33	.11	.89	.67	.45	.22	2.00	6.7	3.3	40.0	6.6	3.3
38	.77	.55	.32	.09	.86	.64	.41	.18	1.96	6.4	2.7	39.1	5.5	1.8
39	.77	.54	.30	.07	.84	.61	.38	.14	.91	6.1	2.1	8.2	4.3	30.3
33 40	25.76	51.53	77.29	103.05	128.81	154.58	180.34	206.10	231.87	1545.8	3091.5	4637.3	6183.1	7728.8
41	.76	.52	.27	.03	.79	.55	.31	.06	.82	5.5	0.9	6.4	1.9	7.3
42	.75	.51	.26	3.01	.76	.52	.27	6.02	.78	5.2	90.3	5.5	80.7	5.9
43	.75	.50	.24	2.99	.74	.49	.24	5.98	.73	4.9	89.8	4.6	79.5	4.4
44	.74	.49	.23	.97	.71	.46	.20	.94	.69	4.6	9.2	3.7	8.3	2.9
33 45	25.74	51.48	77.21	102.95	128.69	154.43	180.17	205.90	231.64	1544.3	3088.6	4632.8	6177.1	7721.4
46	.73	.47	.20	.93	.67	.40	.13	.86	.60	4.0	8.0	1.9	5.9	19.9
47	.73	.46	.18	.91	.64	.37	.10	.82	.55	3.7	7.4	1.0	4.7	8.4
48	.72	.45	.17	.89	.62	.34	.06	.78	.51	3.4	6.8	30.1	3.5	6.9
49	.72	.44	.15	.87	.59	.31	80.03	.74	.46	3.1	6.2	29.2	2.3	5.4
33 50	25.71	51.43	77.14	102.85	128.57	154.28	179.99	205.70	231.42	1542.8	3085.6	4628.3	6171.1	7713.9
51	.71	.42	.12	.83	.55	.25	.96	.66	.37	2.5	5.0	7.4	69.9	2.4
52	.70	.41	.11	.81	.52	.22	.92	.62	.33	2.2	4.4	6.5	8.7	10.9
53	.70	.40	.09	.79	.49	.19	.89	.58	.28	1.9	3.8	5.6	7.5	09.4
54	.69	.39	.08	.77	.47	.16	.85	.54	.24	1.6	3.2	4.7	6.3	7.9
33 55	25.69	51.38	77.06	102.75	128.44	154.13	179.82	205.50	231.19	1541.3	3082.6	4623.8	6165.1	7706.4
56	.68	.37	.05	.73	.42	.10	.78	.46	.15	1.0	2.0	2.9	3.9	4.9
57	.68	.36	.03	.71	.39	.07	.75	.42	.10	0.7	1.4	2.0	2.7	3.4
58	.67	.35	.02	.69	.37	.04	.71	.38	.06	0.4	0.8	1.1	1.5	1.9
59	.67	.34	7.00	.67	.34	4.01	.68	.34	1.01	40.1	80.2	20.2	60.3	700.4
33 60	25.66	51.33	76.99	102.65	128.32	153.98	179.64	205.30	230.97	1539.8	3079.6	4619.3	6159.1	7698.9

Lat.		Latitude 33° to 34°—Meridional arcs.						Latitude 33°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
33	00	30.806			1848.35						
	1	6	1	30.81	.36	1	1 848.4	0	1	1 557.6	0.1
	2	6	2	61.62	.36	2	3 696.7		2	3 115.2	0.5
	3	6	3	92.43	.37	3	5 545.1		3	4 672.8	1.1
	4	6	4	123.23	.37	4	7 393.4		4	6 230.3	2.0
33	05	30.806	5	154.04	1848.38	5	9 241.8	0	5	7 787.9	3.1
	6	6	6	184.85	.38	6	11 090.2		6	9 345.5	4.4
	7	6	7	215.66	.39	7	12 938.6		7	10 903.1	6.0
	8	7	8	246.47	.39	8	14 787.0		8	12 460.7	7.9
	9	7	9	277.28	.40	9	16 635.4		9	14 018.3	10.0
33	10	30.807	10	308.08	1848.40	10	18 483.8	0	10	15 575.9	12.3
	11	7	1	338.89	.41	1	20 332.2		15	23 363.8	27.8
	12	7	2	369.70	.41	2	22 180.6		20	31 151.7	49.4
	13	7	3	400.51	.42	3	24 029.0		25	38 939.6	77.1
	14	7	4	431.32	.42	4	25 877.4		30	46 727.4	111.0
33	15	30.807	15	462.13	1848.43	15	27 725.8	0	35	54 515.3	151.1
	16	7	6	492.93	.43	6	29 574.2		40	62 303.1	197.4
	17	7	7	523.74	.44	7	31 422.7		45	70 090.8	249.8
	18	7	8	554.55	.44	8	33 271.1		50	77 878.6	308.4
	19	7	9	585.36	.45	9	35 119.6		55	85 666.2	373.2
33	20	30.808	20	616.17	1848.45	20	36 968.0	1	00	93 453.8	444.2
	21	8	1	646.98	.46	1	38 816.5		05	101 241.4	521.3
	22	8	2	677.78	.46	2	40 664.9		10	109 028.9	604.6
	23	8	3	708.59	.47	3	42 513.4		15	116 816.3	694.0
	24	8	4	739.40	.47	4	44 361.9		20	124 603.7	789.6
33	25	30.808	25	770.21	1848.48	25	46 210.3	1	25	132 390.9	891.4
	26	8	6	801.02	.48	6	48 058.8		30	140 178.1	999.4
	27	8	7	831.83	.49	7	49 907.3		35	147 965.2	1 113.5
	28	8	8	862.63	.49	8	51 755.8		40	155 752.2	1 233.8
	29	8	9	893.44	.50	9	53 604.3		45	163 539.1	1 360.3
33	30	30.808	30	924.25	1848.50	30	55 452.8	1	50	171 326.0	1 492.9
	31	8	1	955.06	.51	1	57 301.3		55	179 112.7	1 631.7
	32	9	2	985.87	.51	2	59 149.8	2	00	186 899	1 777
	33	9	3	1 016.68	.52	3	60 998.3	3	00	280 328	3 997
	34	9	4	1 047.48	.52	4	62 846.8	4	00	373 731	7 106
33	35	30.809	35	1 078.29	1848.53	35	64 695.3	5	00	467 100	11 102
	36	9	6	1 109.10	.53	6	66 543.9	6	00	560 428	15 986
	37	9	7	1 139.91	.54	7	68 392.4	7	00	653 704	21 757
	38	9	8	1 170.72	.54	8	70 241.0	8	00	746 922	28 414
	39	9	9	1 201.53	.55	9	72 089.5	9	00	840 072	35 957
33	40	30.809	40	1 232.33	1848.55	40	73 938.0	10	00	933 146	44 385
	41	9	1	1 263.14	.56	1	75 786.6	11	00	1 026 136	53 697
	42	9	2	1 293.95	.56	2	77 635.2	12	00	1 119 033	63 893
	43	09	3	1 324.76	.57	3	79 483.7	13	00	1 211 829	74 971
	44	10	4	1 355.57	.57	4	81 332.3	14	00	1 304 515	86 931
33	45	30.810	45	1 386.38	1848.58	45	83 180.9	15	00	1 397 083	99 771
	46	0	6	1 417.18	.58	6	85 029.4	16	00	1 489 526	113 491
	47	0	7	1 447.99	.59	7	86 878.0	17	00	1 581 834	128 089
	48	0	8	1 478.80	.59	8	88 726.6	18	00	1 673 998	143 564
	49	0	9	1 509.61	.60	9	90 575.2	19	00	1 766 011	159 914
33	50	30.810	50	1 540.42	1848.60	50	92 423.8	20	00	1 857 866	177 138
	51	0	1	1 571.23	.61	1	94 272.4	21	00	1 949 553	195 234
	52	0	2	1 602.03	.61	2	96 121.0	22	00	2 041 062	214 201
	53	0	3	1 632.84	.62	3	97 969.6	23	00	2 132 387	234 037
	54	0	4	1 663.65	.62	4	99 818.2	24	00	2 223 521	254 740
33	55	30.810	55	1 694.46	1848.63	55	101 666.9	25	00	2 314 453	276 309
	56	1	6	1 725.27	.63	6	103 515.5	26	00	2 405 175	298 741
	57	1	7	1 756.08	.64	7	105 364.1	27	00	2 495 680	322 034
	58	1	8	1 786.88	.64	8	107 212.8	28	00	2 585 961	346 187
	59	1	9	1 817.69	.65	9	109 061.4	29	00	2 676 007	371 197
33	60	30.811	60	1 848.50	1848.65	60	110 910.1	30	00	2 765 812	397 061

Latitude 34° to 35°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
34 00	25.66	51.33	76.99	102.65	128.32	153.98	179.64	205.30	230.97	1539.8	3079.6	4619.3	6159.1	7698.9
1	.66	.32	.97	.63	.29	.95	.61	.26	.92	9.5	9.0	8.4	7.9	7.4
2	.65	.31	.96	.61	.27	.92	.57	.22	.88	9.2	8.4	7.5	6.7	5.9
3	.65	.30	.94	.59	.24	.89	.54	.18	.83	8.9	7.7	6.6	5.5	4.4
4	.64	.29	.93	.57	.22	.86	.50	.14	.79	8.6	7.1	5.7	4.3	2.9
34 05	25.64	51.28	76.91	102.55	128.19	153.83	179.47	205.10	230.74	1538.3	3076.5	4614.8	6153.1	7691.4
6	.63	.27	.90	.53	.16	.80	.43	.06	.70	8.0	5.9	3.9	1.9	89.9
7	.63	.26	.88	.51	.14	.77	.40	5.02	.65	7.7	5.3	3.0	50.7	8.4
8	.62	.25	.87	.49	.11	.74	.36	4.98	.60	7.4	4.7	2.1	49.5	6.8
9	.62	.24	.85	.47	.09	.71	.33	.94	.56	7.1	4.1	1.2	8.3	5.3
34 10	25.61	51.23	76.84	102.45	128.06	153.68	179.29	204.90	230.51	1536.8	3073.5	4610.3	6147.1	7683.8
11	.61	.22	.82	.43	.04	.65	.26	.86	.47	6.5	2.9	09.4	5.9	2.3
12	.60	.21	.81	.41	8.01	.62	.22	.82	.42	6.2	2.3	8.5	4.6	80.8
13	.60	.20	.79	.39	7.99	.59	.19	.78	.38	5.9	1.7	7.6	3.4	79.3
14	.59	.19	.78	.37	.96	.56	.15	.74	.33	5.6	1.1	6.7	2.2	7.8
34 15	25.59	51.18	76.76	102.35	127.94	153.53	179.12	204.70	230.29	1535.3	3070.5	4605.8	6141.0	7676.3
16	.58	.16	.75	.33	.91	.50	.08	.66	.24	5.0	69.9	4.9	39.8	4.8
17	.58	.15	.73	.31	.89	.46	.04	.62	.20	4.6	9.3	3.9	8.6	3.2
18	.57	.14	.72	.29	.86	.43	9.01	.58	.15	4.3	8.7	3.0	7.4	1.7
19	.57	.13	.70	.27	.84	.40	8.97	.54	.11	4.0	8.1	2.1	6.2	70.2
34 20	25.56	51.12	76.69	102.25	127.81	153.37	178.94	204.50	230.06	1533.7	3067.5	4601.2	6135.0	7668.7
21	.56	.11	.67	.23	.79	.34	.90	.46	30.02	3.4	6.9	600.3	3.7	7.2
22	.55	.10	.66	.21	.76	.31	.87	.42	29.97	3.1	6.3	599.4	2.5	5.7
23	.55	.09	.64	.19	.74	.28	.83	.38	.92	2.8	5.6	8.5	1.3	4.1
24	.54	.08	.63	.17	.71	.25	.80	.34	.88	2.5	5.0	7.6	30.1	2.6
34 25	25.54	51.07	76.61	102.15	127.69	153.22	178.76	204.30	229.83	1532.2	3064.4	4596.7	6128.9	7661.1
26	.53	.06	.60	.13	.66	.19	.72	.26	.79	1.9	3.8	5.8	7.7	59.6
27	.53	.05	.58	.11	.64	.16	.69	.21	.74	1.6	3.2	4.9	6.4	8.1
28	.52	.04	.57	.09	.61	.13	.65	.17	.70	1.3	2.6	3.9	5.2	6.5
29	.52	.03	.55	.07	.59	.10	.62	.13	.65	1.0	2.0	3.0	4.0	5.0
34 30	25.51	51.02	76.54	102.05	127.56	153.07	178.58	204.09	229.61	1530.7	3061.4	4592.1	6122.8	7653.5
31	.51	.01	.52	.03	.53	.04	.55	.05	.56	0.4	0.8	1.2	1.6	2.0
32	.50	1.00	.50	2.01	.51	3.01	.51	4.01	.51	30.1	60.2	90.3	20.4	50.4
33	.50	0.99	.49	1.99	.48	2.98	.48	3.97	.47	29.8	59.6	89.3	19.1	48.9
34	.49	.98	.47	.97	.46	.95	.44	.93	.42	9.5	9.0	8.4	7.9	7.4
34 35	25.49	50.97	76.46	101.94	127.43	152.92	178.41	203.89	229.38	1529.2	3058.3	4587.5	6116.7	7645.9
36	.48	.96	.44	.92	.40	.89	.37	.85	.33	8.9	7.7	6.6	5.5	4.3
37	.48	.95	.43	.90	.38	.86	.34	.81	.28	8.6	7.1	5.7	4.2	2.8
38	.47	.94	.41	.88	.35	.83	.30	.77	.24	8.3	6.5	4.8	3.0	41.3
39	.47	.93	.40	.86	.33	.80	.27	.73	.19	8.0	5.9	3.9	1.8	39.8
34 40	25.46	50.92	76.38	101.84	127.30	152.76	178.23	203.69	229.15	1527.6	3055.3	4582.9	6110.6	7638.2
41	.46	.91	.37	.82	.28	.73	.19	.65	.10	7.3	4.7	2.0	09.4	6.7
42	.45	.90	.35	.80	.25	.70	.16	.61	.06	7.0	4.1	1.1	8.2	5.2
43	.45	.89	.34	.78	.23	.67	.12	.56	9.01	6.7	3.4	80.1	6.9	3.6
44	.44	.88	.32	.76	.20	.64	.08	.52	8.96	6.4	2.8	79.2	5.7	2.1
34 45	25.44	50.87	76.31	101.74	127.17	152.61	178.05	203.48	228.92	1526.1	3052.2	4578.3	6104.5	7630.6
46	.43	.86	.29	.72	.15	.58	8.01	.44	.87	5.8	1.6	7.4	3.2	29.0
47	.43	.85	.28	.70	.12	.55	7.98	.40	.83	5.5	1.0	6.5	2.0	7.5
48	.42	.84	.26	.68	.10	.52	.94	.36	.78	5.2	50.4	5.5	100.8	6.0
49	.42	.83	.24	.66	.07	.49	.91	.32	.73	4.9	49.8	4.6	099.6	4.4
34 50	25.41	50.82	76.23	101.64	127.05	152.46	177.87	203.28	228.69	1524.6	3049.2	4573.7	6098.3	7622.9
51	.41	.81	.21	.62	.02	.43	.83	.24	.64	4.3	8.6	2.8	7.1	21.4
52	.40	.80	.20	.60	7.00	.40	.80	.20	.59	4.0	8.0	1.9	5.9	19.8
53	.40	.79	.18	.58	6.97	.37	.76	.15	.55	3.7	7.3	1.0	4.6	8.3
54	.39	.78	.17	.56	.95	.34	.73	.11	.50	3.4	6.7	70.1	3.4	6.8
34 55	25.39	50.77	76.15	101.54	126.92	152.30	177.69	203.07	228.46	1523.0	3046.1	4569.1	6092.2	7615.2
56	.38	.76	.14	.52	.89	.27	.65	3.03	.41	2.7	5.5	8.2	90.9	3.7
57	.38	.75	.12	.49	.87	.24	.62	2.99	.36	2.4	4.8	7.3	89.7	2.1
58	.37	.74	.11	.47	.84	.21	.58	.95	.32	2.1	4.2	6.3	8.5	10.6
59	.37	.73	.09	.45	.82	.18	.55	.91	.27	1.8	3.6	5.4	7.2	09.1
34 60	25.36	50.72	76.08	101.43	126.79	152.15	177.51	202.87	228.23	1521.5	3043.0	4564.5	6086.0	7607.5

Lat.		Latitude 34° to 35°—Meridional arcs.						Latitude 34°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
34	00	30.811			1848.65						
	1	1	1	30.81	.66	1	1 848.7	0	1	1 539.8	0.1
	2	1	2	61.63	.66	2	3 697.3		2	3 079.6	0.5
	3	1	3	92.44	.67	3	5 546.0		3	4 619.3	1.1
	4	1	4	123.25	.67	4	7 394.6		4	6 159.1	2.0
34	05	30.811	5	154.07	1848.68	5	9 243.3	0	5	7 698.9	3.1
	6	1	6	184.88	.68	6	11 092.0		6	9 238.7	4.5
	7	1	7	215.69	.69	7	12 940.7		7	10 778.5	6.1
	8	2	8	246.51	.69	8	14 789.4		8	12 318.3	8.0
	9	2	9	277.32	.70	9	16 638.1		9	13 858.0	10.1
34	10	30.812	10	308.13	1848.70	10	18 486.8	0	10	15 397.9	12.5
	11	2	1	338.95	.71	1	20 335.5		15	23 096.7	28.2
	12	2	2	369.76	.71	2	22 184.2		20	30 795.6	50.1
	13	2	3	400.57	.72	3	24 032.9		25	38 494.4	78.3
	14	2	4	431.39	.72	4	25 881.6		30	46 193.2	112.7
34	15	30.812	15	462.20	1848.73	15	27 730.4	0	35	53 892.0	153.4
	16	2	6	493.01	.73	6	29 579.1		40	61 590.8	200.4
	17	2	7	523.83	.74	7	31 427.8		45	69 289.5	253.6
	18	2	8	554.64	.74	8	33 276.6		50	76 988.2	313.1
	19	2	9	585.46	.75	9	35 125.3		55	84 686.8	378.8
34	20	30.813	20	616.27	1848.75	20	36 974.1	1	00	92 385.4	450.8
	21	3	1	647.08	.76	1	38 822.8		05	100 083.9	529.1
	22	3	2	677.90	.76	2	40 671.6		10	107 782.3	613.6
	23	3	3	708.71	.77	3	42 520.3		15	115 480.7	704.4
	24	3	4	739.52	.78	4	44 369.1		20	123 179.0	801.5
34	25	30.813	25	770.34	1848.78	25	46 217.9	1	25	130 877.2	904.8
	26	3	6	801.15	.79	6	48 066.7		30	138 575.3	1 014.4
	27	3	7	831.96	.79	7	49 915.5		35	146 273.4	1 130.2
	28	3	8	862.78	.80	8	51 764.3		40	153 971.3	1 252.3
	29	3	9	893.59	.80	9	53 613.1		45	161 669.2	1 380.7
34	30	30.813	30	924.40	1848.81	30	55 461.9	1	50	169 366.9	1 515.3
	31	4	1	955.22	.81	1	57 310.7		55	177 064.5	1 656.1
	32	4	2	986.03	.82	2	59 159.5	2	00	184 762	1 803
	33	4	3	1 016.84	.82	3	61 008.3	3	00	277 121	4 057
	34	4	4	1 047.66	.83	4	62 857.1	4	00	369 454	7 212
34	35	30.814	35	1 078.47	1848.83	35	64 705.9	5	00	461 751	11 268
	36	4	6	1 109.28	.84	6	66 554.8	6	00	554 004	16 225
	37	4	7	1 140.10	.84	7	68 403.6	7	00	646 205	22 082
	38	4	8	1 170.91	.85	8	70 252.5	8	00	738 344	28 8[illegible]9
	39	4	9	1 201.72	.85	9	72 101.3	9	00	830 413	36 494
34	40	30.814	40	1 232.54	1848.86	40	73 950.2	10	00	922 403	45 048
	41	4	1	1 263.35	.86	1	75 799.0	11	00	1 014 305	54 499
	42	4	2	1 294.16	.87	2	77 647.9	12	00	1 106 110	64 846
	43	5	3	1 324.98	.87	3	79 496.8	13	00	1 197 809	76 089
	44	5	4	1 355.79	.88	4	81 345.6	14	00	1 289 395	88 227
34	45	30.815	45	1 386.60	1848.88	45	83 194.5	15	00	1 380 858	101 258
	46	5	6	1 417.42	.89	6	85 043.4	16	00	1 472 190	115 180
	47	5	7	1 448.23	.89	7	86 892.3	17	00	1 563 381	129 993
	48	5	8	1 479.04	.90	8	88 741.2	18	00	1 654 423	145 696
	49	5	9	1 509.86	.90	9	90 590.1	19	00	1 745 308	162 287
34	50	30.815	50	1 540.67	1848.91	50	92 439.0	20	00	1 836 026	179 763
	51	5	1	1 571.48	.91	1	94 287.9	21	00	1 926 569	198 124
	52	5	2	1 602.30	.92	2	96 136.8	22	00	2 016 929	217 368
	53	5	3	1 633.11	.92	3	97 985.7	23	00	2 107 097	237 493
	54	5	4	1 663.93	.93	4	99 834.7	24	00	2 197 065	258 497
34	55	30.816	55	1 694.74	1848.93	55	101 683.6	25	00	2 286 823	280 378
	56	6	6	1 725.55	.94	6	103 532.5	26	00	2 376 363	303 134
	57	6	7	1 756.37	.94	7	105 381.5	27	00	2 465 677	326 763
	58	6	8	1 787.18	.95	8	107 230.4	28	00	2 554 756	351 262
	59	6	9	1 817.99	.95	9	109 079.4	29	00	2 643 591	376 629
34	60	30.816	60	1 848.81	1848.96	60	110 928.3	30	00	2 732 175	402 863

Latitude 35° to 36°—Arcs of the parallel in meters.

Lat. ° ′	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
35 00	25.36	50.72	76.08	101.43	126.79	152.15	177.51	202.87	228.23	1521.5	3043.0	4564.5	6086.0	7607.5
1	.35	.71	.06	.41	.76	.12	.47	.83	.18	1.2	2.4	3.6	4.8	6.0
2	.35	.70	.04	.39	.74	.09	.44	.78	.14	0.9	1.8	2.7	3.5	4.4
3	.34	.69	.03	.37	.71	.06	.40	.74	.09	0.6	1.2	1.7	2.3	2.9
4	.34	.68	.01	.35	.69	.03	.37	.70	.04	0.3	40.5	60.8	81.1	601.3
35 05	25.33	50.67	76.00	101.33	126.66	152.00	177.33	202.66	228.00	1520.0	3039.9	4559.9	6079.8	7599.8
6	.33	.65	5.98	.31	.63	1.96	.29	.62	7.95	19.6	9.3	9.0	8.6	8.2
7	.32	.64	.97	.29	.61	.93	.26	.58	.91	9.3	8.7	8.0	7.4	6.7
8	.32	.63	.95	.27	.58	.90	.22	.54	.86	9.0	8.0	7.1	6.1	5.1
9	.31	.62	.94	.25	.56	.87	.19	.50	.81	8.7	7.4	6.1	4.9	3.6
35 10	25.31	50.61	75.92	101.23	126.53	151.84	177.15	202.46	227.76	1518.4	3036.8	4555.2	6073.7	7592.1
11	.30	.60	.91	.21	.51	.81	.11	.41	.72	8.1	6.2	4.3	2.4	90.5
12	.30	.59	.89	.19	.48	.78	.08	.37	.67	7.8	5.6	3.4	71.1	88.9
13	.29	.58	.87	.17	.46	.75	.04	.33	.62	7.5	5.0	2.4	69.9	7.4
14	.29	.57	.86	.14	.43	.72	7.01	.29	.58	7.2	4.3	1.5	8.6	5.8
35 15	25.28	50.56	75.84	101.12	126.41	151.69	176.97	202.25	227.53	1516.9	3033.7	4550.6	6067.4	7584.3
16	.28	.55	.83	.10	.38	.65	.93	.21	.49	6.5	3.1	49.7	6.2	2.7
17	.27	.54	.81	.08	.35	.62	.90	.17	.44	6.2	2.5	8.7	5.0	81.2
18	.27	.53	.80	.06	.33	.59	.86	.12	.39	5.9	1.8	7.8	3.7	79.6
19	.26	.52	.78	.04	.30	.56	.82	.08	.34	5.6	1.2	6.8	2.5	8.1
35 20	25.26	50.51	75.77	101.02	126.28	151.53	176.79	202.04	227.30	1515.3	3030.6	4545.9	6061.2	7576.5
21	.25	.50	.75	1.00	.25	.50	.75	2.00	.25	5.0	30.0	5.0	60.0	5.0
22	.24	.49	.73	0.98	.23	.47	.72	1.96	.20	4.7	29.4	4.0	58.7	3.4
23	.24	.48	.72	.96	.20	.44	.68	.92	.16	4.4	8.8	3.1	7.5	1.9
24	.23	.47	.70	.94	.18	.41	.64	.87	.11	4.1	8.1	2.1	6.2	70.3
35 25	25.23	50.46	75.69	100.92	126.15	151.37	176.60	201.83	227.06	1513.7	3027.5	4541.2	6055.0	7568.7
26	.22	.45	.67	.90	.12	.34	.57	.79	7.02	3.4	6.9	40.3	3.8	7.2
27	.22	.44	.66	.87	.09	.31	.53	.75	6.97	3.1	6.2	39.4	2.5	5.6
28	.21	.43	.64	.85	.07	.28	.49	.71	.92	2.8	5.6	8.4	1.3	4.1
29	.21	.42	.63	.83	.04	.25	.46	.67	.88	2.5	5.0	7.5	50.0	2.5
35 30	25.20	50.41	75.61	100.81	126.02	151.22	176.42	201.63	226.83	1512.2	3024.4	4536.6	6048.8	7561.0
31	.20	.40	.59	.79	5.99	.19	.38	.58	.78	1.9	3.8	5.7	7.5	59.4
32	.19	.39	.58	.77	.97	.16	.35	.54	.74	1.6	3.1	4.7	6.2	7.8
33	.19	.38	.56	.75	.94	.13	.31	.50	.69	1.3	2.5	3.8	5.0	6.3
34	.18	.36	.55	.73	.91	.09	.28	.46	.64	0.9	1.9	2.8	3.8	4.7
35 35	25.18	50.35	75.53	100.71	125.88	151.06	176.24	201.42	226.60	1510.6	3021.2	4531.9	6042.5	7553.1
36	.17	.34	.52	.69	.86	.03	.20	.38	.55	0.3	0.6	1.0	1.3	1.6
37	.17	.33	.50	.67	.84	1.00	.17	.33	.50	10.0	20.0	30.0	40.0	50.0
38	.16	.32	.48	.65	.81	0.97	.13	.29	.45	09.7	19.4	29.1	38.7	48.4
39	.16	.31	.47	.63	.79	.94	.10	.25	.41	9.4	8.8	8.1	7.5	6.9
35 40	25.15	50.30	75.45	100.60	125.76	150.91	176.06	201.21	226.36	1509.1	3018.1	4527.2	6036.2	7545.3
41	.15	.29	.44	.58	.73	.87	6.02	.17	.31	8.7	7.5	6.3	5.0	3.7
42	.14	.28	.42	.56	.70	.84	5.99	.13	.27	8.4	6.9	5.3	3.8	2.2
43	.14	.27	.41	.54	.68	.81	.95	.08	.22	8.1	6.2	4.4	2.5	40.6
44	.13	.26	.39	.52	.65	.78	.91	.04	.17	7.8	5.6	3.4	31.2	39.0
35 45	25.12	50.25	75.37	100.50	125.62	150.75	175.87	201.00	226.12	1507.5	3015.0	4522.5	6029.9	7537.4
46	.12	.24	.36	.48	.60	.72	.84	0.96	.08	7.2	4.4	1.6	8.7	5.9
47	.11	.23	.34	.46	.57	.69	.80	.91	6.03	6.9	3.7	20.6	7.4	4.3
48	.11	.22	.33	.44	.54	.65	.76	.87	5.98	6.5	3.1	19.7	6.2	2.7
49	.10	.21	.31	.42	.52	.62	.72	.83	.94	6.2	2.5	8.7	5.0	31.2
35 50	25.10	50.20	75.30	100.39	125.49	150.59	175.69	200.79	225.89	1505.9	3011.8	4517.8	6023.7	7529.6
51	.09	.19	.28	.37	.46	.56	.65	.75	.84	5.6	1.2	6.8	2.4	8.0
52	.09	.18	.26	.35	.44	.53	.62	.70	.79	5.3	0.6	5.9	21.1	6.4
53	.08	.17	.25	.33	.41	.50	.58	.66	.75	5.0	10.0	4.9	19.9	4.9
54	.08	.16	.23	.31	.39	.47	.54	.62	.70	4.7	09.3	4.0	8.6	3.3
35 55	25.07	50.14	75.22	100.29	125.36	150.43	175.50	200.58	225.65	1504.3	3008.7	4513.0	6017.4	7521.7
56	.07	.13	.20	.27	.33	.40	.47	.54	.60	4.0	8.0	2.1	6.1	20.1
57	.06	.12	.19	.25	.31	.37	.43	.49	.55	3.7	7.4	1.1	4.8	18.5
58	.06	.11	.17	.23	.28	.34	.39	.45	.51	3.4	6.8	10.2	3.6	7.0
59	.05	.10	.15	.21	.26	.31	.36	.41	.46	3.1	6.2	09.2	2.3	5.4
35 60	25.05	50.09	75.14	100.18	125.23	150.28	175.32	200.37	225.41	1502.8	3005.5	4508.3	6011.0	7513.8

Lat.		Latitude 35° to 36°—Meridional arcs.						Latitude 35°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
35	00	30.816			1848.96						
	1	6	1	30.82	.96	1	1 849.0	0	1	1 521.5	0.1
	2	6	2	61.64	.97	2	3 697.9		2	3 043.0	0.5
	3	6	3	92.46	.97	3	5 546.9		3	4 564.5	1.1
	4	6	4	123.27	.98	4	7 395.9		4	6 086.0	2.0
35	05	30.816	5	154.09	1848.99	5	9 244.9	0	5	7 607.5	3.2
	6	7	6	184.91	8.99	6	11 093.9		6	9 129.0	4.6
	7	7	7	215.73	9.00	7	12 942.8		7	10 650.5	6.2
	8	7	8	246.55	.00	8	14 791.8		8	12 172.0	8.1
	9	7	9	277.37	.01	9	16 640.8		9	13 693.5	10.3
35	10	30.817	10	308.19	1849.01	10	18 489.9	0	10	15 215.0	12.7
	11	7	1	339.00	.02	11	20 338.9		15	22 822.5	28.6
	12	7	2	369.82	.02	12	22 187.9		20	30 430.0	50.8
	13	7	3	400.64	.03	13	24 036.9		25	38 037.5	79.3
	14	7	4	431.46	.03	14	25 885.9		30	45 645.0	114.2
35	15	30.817	15	462.28	1849.04	15	27 735.0	0	35	53 252.4	155.5
	16	7	6	493.10	.04	16	29 584.0		40	60 859.7	203.1
	17	7	7	523.92	.05	17	31 433.1		45	68 467.1	257.0
	18	8	8	554.73	.05	18	33 282.1		50	76 074.3	317.3
	19	8	9	585.55	.06	19	35 131.2		55	83 681.6	384.0
35	20	30.818	20	616.37	1849.06	20	36 980.2	1	00	91 288.8	456.9
	21	8	1	647.19	.07	21	38 829.3		05	98 895.9	536.3
	22	8	2	678.01	.07	22	40 678.4		10	106 502.9	622.0
	23	8	3	708.83	.08	23	42 527.4		15	114 109.9	714.0
	24	8	4	739.65	.08	24	44 376.5		20	121 716.8	812.4
35	25	30.818	25	770.46	1849.09	25	46 225.6	1	25	129 323.6	917.1
	26	8	6	801.28	.09	26	48 074.7		30	136 930.3	1 028.1
	27	8	7	832.10	.10	27	49 923.8		35	144 536.9	1 145.5
	28	8	8	862.92	.10	28	51 772.9		40	152 143.4	1 269.3
	29	8	9	893.74	.11	29	53 622.0		45	159 749.8	1 399.4
35	30	30.819	30	924.56	1849.11	30	55 471.1	1	50	167 356.1	1 535.8
	31	9	1	955.38	.12	31	57 320.2		55	174 962.3	1 678.6
	32	9	2	986.19	.12	32	59 169.4	2	00	182 568	1 828
	33	9	3	1 017.01	.13	33	61 018.5	3	00	273 830	4 112
	34	9	4	1 047.83	.13	34	62 867.6	4	00	365 064	7 310
35	35	30.819	35	1 078.65	1849.14	35	64 716.7	5	00	456 261	11 421
	36	9	6	1 109.47	.15	36	66 565.9	6	00	547 412	16 445
	37	9	7	1 140.29	.15	37	68 415.0	7	00	638 509	22 381
	38	9	8	1 171.11	.16	38	70 264.2	8	00	729 542	29 229
	39	9	9	1 201.92	.16	39	72 113.3	9	00	820 501	36 987
35	40	30.819	40	1 232.74	1849.17	40	73 962.5	10	00	911 379	45 656
	41	20	1	1 263.56	.17	41	75 811.7	11	00	1 002 165	55 234
	42	0	2	1 294.38	.18	42	77 660.8	12	00	1 092 850	65 721
	43	0	3	1 325.20	.18	43	79 510.0	13	00	1 183 426	77 115
	44	0	4	1 356.02	.19	44	81 359.2	14	00	1 273 884	89 415
35	45	30.820	45	1 386.84	1849.19	45	83 208.4	15	00	1 364 214	102 619
	46	0	6	1 417.65	.20	46	85 057.6	16	00	1 454 407	116 728
	47	0	7	1 448.47	.20	47	86 906.8	17	00	1 544 454	131 738
	48	0	8	1 479.29	.21	48	88 756.0	18	00	1 634 347	147 650
	49	0	9	1 510.11	.21	49	90 605.2	19	00	1 724 076	164 460
35	50	30.820	50	1 540.93	1849.22	50	92 454.4	20	00	1 813 632	182 168
	51	0	1	1 571.75	.22	51	94 303.6	21	00	1 903 006	200 772
	52	0	2	1 602.57	.23	52	96 152.9	22	00	1 992 190	220 268
	53	1	3	1 633.38	.23	53	98 002.1	23	00	2 081 174	240 657
	54	1	4	1 664.20	1849.24	54	99 851.3	24	00	2 169 949	261 936
35	55	30.821	55	1 695.02	.24	55	101 700.6	25	00	2 258 507	284 102
	56	1	6	1 725.84	.25	56	103 549.8	26	00	2 346 838	307 154
	57	1	7	1 756.66	.25	57	105 399.1	27	00	2 434 934	331 089
	58	1	8	1 787.48	.26	58	107 248.3	28	00	2 522 787	355 905
	59	1	9	1 818.30	.26	59	109 097.6	29	00	2 610 386	381 598
35	60	30.821	60	1 849.11	1849.27	60	110 946.9	30	00	2 697 724	408 168

Latitude 36° to 37°—Arcs of the Parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
36 00	25.05	50.09	75.14	100.18	125.23	150.28	175.32	200.37	225.41	1502.8	3005.5	4508.3	6011.0	7513.8
1	.04	.08	.12	.16	.20	.25	.29	.33	.36	2.5	4.9	7.3	09.8	2.2
2	.04	.07	.11	.14	.18	.22	.25	.28	.32	2.2	4.3	6.4	8.5	10.6
3	.03	.06	.09	.12	.15	.18	.21	.24	.27	1.8	3.6	5.4	7.2	09.1
4	.03	.05	.08	.10	.13	.15	.17	.20	.22	1.5	3.0	4.5	6.0	7.5
36 05	25.02	50.04	75.06	100.08	125.10	150.12	175.14	200.16	225.17	1501.2	3002.4	4503.5	6004.7	7505.9
6	.01	.03	.04	.06	.07	.09	.10	.11	.13	0.9	1.7	2.6	3.4	4.3
7	.01	.02	.03	.04	.05	.06	.06	.07	.08	0.6	1.1	1.6	2.2	2.7
8	.00	.01	.01	100.02	5.02	50.02	5.02	200.03	5.03	500.2	3000.5	500.7	6000.9	501.1
9	5.00	50.00	5.00	99.99	4.99	49.99	4.99	199.99	4.99	499.9	2999.8	499.7	5999.6	499.6
36 10	24.99	49.99	74.98	99.97	124.97	149.96	174.95	199.95	224.94	1499.6	2999.2	4498.8	5998.4	7498.0
11	.99	.98	.96	.95	.94	.93	.91	.90	.89	9.3	8.6	7.8	7.1	6.4
12	.98	.97	.95	.93	.92	.90	.88	.86	.84	9.0	7.9	6.9	5.8	4.8
13	.98	.95	.93	.91	.89	.86	.84	.82	.80	8.6	7.3	5.9	4.6	3.2
14	.97	.94	.92	.89	.86	.83	.80	.78	.75	8.3	6.6	5.0	3.3	1.6
36 15	24.97	49.93	74.90	99.87	124.84	149.80	174.77	199.73	224.70	1498.0	2996.0	4494.0	5992.0	7490.0
16	.96	.92	.88	.85	.81	.77	.73	.69	.65	7.7	5.4	3.0	90.7	88.4
17	.96	.91	.87	.82	.78	.74	.69	.65	.60	7.4	4.7	2.1	89.5	6.8
18	.95	.90	.85	.80	.75	.70	.65	.61	.56	7.0	4.1	1.1	8.2	5.2
19	.95	.89	.84	.78	.73	.67	.62	.56	.51	6.7	3.4	90.2	6.9	3.7
36 20	24.94	49.88	74.82	99.76	124.70	149.64	174.58	199.52	224.46	1496.4	2992.8	4489.2	5985.7	7482.1
21	.94	.87	.80	.74	.67	.61	.54	.48	.41	6.1	2.2	8.3	4.4	80.5
22	.93	.86	.79	.72	.65	.58	.51	.44	.36	5.8	1.5	7.3	3.1	78.9
23	.93	.85	.77	.70	.62	.54	.47	.39	.32	5.4	0.9	6.4	1.8	7.3
24	.92	.84	.76	.67	.59	.51	.43	.35	.27	5.1	90.2	5.4	80.5	5.7
36 25	24.91	49.83	74.74	99.65	124.57	149.48	174.39	199.31	224.22	1494.8	2989.6	4484.5	5979.3	7474.1
26	.91	.82	.72	.63	.54	.45	.36	.27	.17	4.5	9.0	3.5	8.0	2.5
27	.90	.81	.71	.61	.52	.42	.32	.22	.13	4.2	8.3	2.6	6.7	70.9
28	.90	.79	.69	.59	.49	.38	.28	.18	.08	3.8	7.7	1.6	5.4	69.3
29	.89	.78	.68	.57	.46	.35	.25	.14	4.03	3.5	7.0	80.7	4.2	7.7
36 30	24.89	49.77	74.66	99.55	124.44	149.32	174.21	199.10	223.98	1493.2	2986.4	4479.7	5972.9	7466.1
31	.88	.76	.64	.53	.41	.29	.17	.05	.93	2.9	5.8	8.7	1.6	4.5
32	.88	.75	.63	.50	.38	.26	.14	9.01	.88	2.6	5.1	7.7	70.3	2.9
33	.87	.74	.61	.48	.35	.22	.10	8.97	.84	2.2	4.5	6.8	69.0	61.3
34	.87	.73	.60	.46	.33	.19	.06	.92	.79	1.9	3.8	5.8	7.7	59.7
36 35	24.86	49.72	74.58	99.44	124.30	149.16	174.02	198.88	223.74	1491.6	2983.2	4474.8	5966.5	7458.1
36	.85	.71	.56	.42	.28	.13	3.99	.84	.69	1.3	2.6	3.8	5.2	6.5
37	.85	.70	.55	.40	.25	.10	.95	.80	.64	1.0	1.9	2.9	3.9	4.9
38	.84	.69	.53	.38	.22	.06	.91	.75	.60	0.6	1.3	1.9	2.6	3.3
39	.84	.68	.52	.35	.19	.03	.87	.71	.55	0.3	0.6	1.0	1.3	1.7
36 40	24.83	49.67	74.50	99.33	124.17	149.00	173.84	198.67	223.50	1490.0	2980.0	4470.0	5960.1	7450.1
41	.83	.66	.48	.31	.14	8.97	.80	.63	.45	89.7	79.4	69.0	58.8	48.5
42	.82	.65	.47	.29	.12	.94	.76	.58	.40	9.4	8.7	8.1	7.5	6.8
43	.82	.63	.45	.27	.09	.90	.72	.54	.36	9.0	8.1	7.1	6.2	5.2
44	.81	.62	.44	.25	.06	.87	.69	.50	.31	8.7	7.4	6.2	4.9	3.6
36 45	24.81	49.61	74.42	99.23	124.03	148.84	173.65	198.45	223.26	1488.4	2976.8	4465.2	5953.6	7442.0
46	.80	.60	.40	.21	4.01	.81	.61	.41	.21	8.1	6.2	4.2	2.3	40.4
47	.80	.59	.39	.18	3.98	.78	.57	.37	.16	7.8	5.5	3.3	51.0	38.8
48	.79	.58	.37	.16	.95	.74	.54	.33	.12	7.4	4.9	2.3	49.8	7.2
49	.79	.57	.36	.14	.93	.71	.50	.28	.07	7.1	4.2	1.4	8.5	5.6
36 50	24.78	49.56	74.34	99.12	123.90	148.68	173.46	198.24	223.02	1486.8	2973.6	4460.4	5947.2	7434.0
51	.78	.55	.32	.10	.87	.65	.42	.20	2.97	6.5	3.0	59.4	5.9	2.4
52	.77	.54	.31	.08	.85	.62	.38	.15	.92	6.2	2.3	8.4	4.6	30.7
53	.76	.53	.29	.06	.82	.58	.35	.11	.87	5.8	1.7	7.5	3.3	29.1
54	.76	.52	.28	.03	.79	.55	.31	.07	.82	5.5	1.0	6.5	2.0	7.5
36 55	24.75	49.51	74.26	99.01	123.76	148.52	173.27	198.02	222.78	1485.2	2970.4	4455.5	5940.7	7425.9
56	.75	.50	.24	8.99	.74	.49	.23	7.98	.73	4.9	69.7	4.5	39.4	4.3
57	.74	.49	.23	.97	.71	.46	.20	.94	.68	4.6	9.1	3.6	8.1	2.7
58	.74	.47	.21	.95	.68	.42	.16	.89	.63	4.2	8.4	2.6	6.8	21.0
59	.73	.46	.19	.93	.66	.39	.12	.85	.58	3.9	7.8	1.7	5.5	19.4
36 60	24.73	49.45	74.18	98.90	123.63	148.36	173.08	197.81	222.53	1483.6	2967.1	4450.7	5934.3	7417.8

Lat.		Latitude 36° to 37°—Meridional arcs.						Latitude 36°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
36	00	30.821			1849.27						
	1	1	1	30.82	.28	1	1 849.3	0	1	1 502.8	0.1
	2	1	2	61.65	.28	2	3 698.5		2	3 005.5	0.5
	3	1	3	92.47	.29	3	5 547.8		3	4 508.3	1.2
	4	2	4	123.29	.29	4	7 397.1		4	6 011.1	2.1
36	05	30.822	5	154.12	1849.30	5	9 246.4	0	5	7 513.8	3.2
	6	2	6	184.94	.30	6	11 095.7		6	9 016.6	4.6
	7	2	7	215.77	.31	7	12 945.0		7	10 519.3	6.3
	8	2	8	246.59	.31	8	14 794.3		8	12 022.1	8.2
	9	2	9	277.41	.32	9	16 643.6		9	13 524.8	10.4
36	10	30.822	10	308.24	1849.32	10	18 493.0	0	10	15 027.6	12.8
	11	2	1	339.06	.33	1	20 342.3		15	22 541.4	28.9
	12	2	2	369.89	.33	2	22 191.6		20	30 055.2	51.4
	13	2	3	400.71	.34	3	24 040.9		25	37 568.9	80.3
	14	2	4	431.53	.34	4	25 890.3		30	45 082.7	115.6
36	15	30.822	15	462.36	1849.35	15	27 739.6	0	35	52 596.4	157.4
	16	3	6	493.18	.35	6	29 589.0		40	60 110.0	205.6
	17	3	7	524.00	.36	7	31 438.3		45	67 623.6	260.2
	18	3	8	554.83	.36	8	33 287.7		50	75 137.3	321.2
	19	3	9	585.65	.37	9	35 137.1		55	82 650.8	388.7
36	20	30.823	20	616.48	1849.37	20	36 986.4	1	00	90 164.3	462.5
	21	3	1	647.30	.38	1	38 835.8		05	97 677.7	542.8
	22	3	2	678.12	.38	2	40 685.2		10	105 191.0	629.5
	23	3	3	708.95	.39	3	42 534.6		15	112 704.2	722.6
	24	3	4	739.77	.40	4	44 384.0		20	120 217.4	822.2
36	25	30.823	25	770.59	1849.40	25	46 233.4	1	25	127 730.4	928.2
	26	3	6	801.42	.41	6	48 082.8		20	135 243.4	1 040.6
	27	4	7	832.24	.41	7	49 932.2		35	142 756.3	1 159.4
	28	4	8	863.07	.42	8	51 781.6		40	150 269.1	1 284.7
	29	4	9	893.89	.42	9	53 631.0		45	157 781.7	1 416.4
36	30	30.824	30	924.71	1849.43	30	55 480.4	1	50	165 294.3	1 554.5
	31	4	1	955.54	.43	1	57 329.9		55	172 806.8	1 699.0
	32	4	2	986.36	.44	2	59 179.3	2	00	180 319	1 850
	33	4	3	1 017.18	.44	3	61 028.7	3	00	270 455	4 162
	34	4	4	1 048.01	.45	4	62 878.2	4	00	360 562	7 399
36	35	30.824	35	1 078.83	1849.45	35	64 727.6	5	00	450 631	11 560
	36	4	6	1 109.66	.46	6	66 577.1	6	00	540 653	16 645
	37	4	7	1 140.48	.46	7	68 426.6	7	00	630 618	22 652
	38	4	8	1 171.30	.47	8	70 276.0	8	00	720 517	29 583
	39	5	9	1 202.13	.47	9	72 125.5	9	00	810 340	37 435
36	40	30.825	40	1 232.95	1849.48	40	73 975.0	10	00	900 078	46 209
	41	5	1	1 263.77	.48	1	75 824.5	11	00	989 720	55 903
	42	5	2	1 294.60	.49	2	77 673.9	12	00	1 079 259	66 515
	43	5	3	1 325.42	.49	3	79 523.4	13	00	1 168 684	78 046
	44	5	4	1 356.25	.50	4	81 372.9	14	00	1 257 987	90 494
36	45	30.825	45	1 387.07	1849.51	45	83 222.4	15	00	1 347 156	103 856
	46	5	6	1 417.89	.51	6	85 071.9	16	00	1 436 184	118 133
	47	5	7	1 448.72	.52	7	86 922.5	17	00	1 525 061	133 323
	48	5	8	1 479.54	.52	8	88 772.0	18	00	1 613 777	149 423
	49	5	9	1 510.36	.53	9	90 620.5	19	00	1 702 324	166 433
36	50	30.826	50	1 541.19	1849.53	50	92 470.0	20	00	1 790 691	184 350
	51	6	1	1 572.01	.54	1	94 319.6	21	00	1 878 870	203 173
	52	6	2	1 602.84	.54	2	96 169.1	22	00	1 966 851	222 899
	53	6	3	1 633.66	.55	3	98 018.6	23	00	2 054 625	243 527
	54	6	4	1 664.48	.55	4	99 868.2	24	00	2 142 183	265 055
36	55	30.826	55	1 695.31	1849.56	55	101 717.8	25	00	2 229 516	287 479
	56	6	6	1 726.13	.56	6	103 567.3	26	00	2 316 613	310 798
	57	6	7	1 756.95	.57	7	105 416.9	27	00	2 403 467	335 009
	58	6	8	1 787.78	.57	8	107 266.5	28	00	2 490 068	360 111
	59	6	9	1 818.60	.58	9	109 116.0	29	00	2 576 407	386 099
36	60	30.826	60	1 849.43	1849.58	60	110 965.6	30	00	2 662 475	412 971

Latitude 37° to 38°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
37 00	24.73	49.45	74.18	98.90	123.63	148.36	173.08	197.81	222.53	1483.6	2967.1	4450.7	5934.3	7417.8
1	.72	.44	.16	.88	.60	.33	.05	.77	.48	3.3	6.5	49.7	3.0	6.3
2	.72	.43	.15	.86	.57	.29	3.00	.72	.43	2.9	5.8	8.7	1.7	4.6
3	.71	.42	.13	.84	.55	.26	2.97	.68	.39	2.6	5.2	7.8	30.4	2.9
4	.70	.41	.11	.82	.52	.23	.93	.64	.34	2.3	4.5	6.8	29.1	1.3
37 05	24.70	49.40	74.10	98.80	123.49	148.19	172.89	197.59	222.29	1481.9	2963.9	4445.8	5927.8	7409.7
6	.69	.39	.08	.77	.46	.16	.85	.55	.24	1.6	3.2	4.8	6.5	8.1
7	.69	.38	.07	.75	.43	.13	.82	.51	.19	1.3	2.6	3.9	5.2	6.5
8	.68	.36	.05	.73	.41	.10	.78	.46	.15	1.0	1.9	2.9	3.9	4.8
9	.68	.35	.03	.71	.38	.06	.74	.42	.10	0.6	1.3	2.0	2.6	3.2
37 10	24.67	49.34	74.02	98.69	123.36	148.03	172.70	197.38	222.05	1480.3	2960.6	4441.0	5921.3	7401.6
11	.67	.33	4.00	.67	.33	8.00	.66	.33	2.00	80.0	60.0	40.0	20.0	400.0
12	.66	.32	3.98	.64	.30	7.97	.63	.29	1.95	79.7	59.3	39.0	18.7	398.3
13	.66	.31	.97	.62	.27	.93	.59	.25	.90	9.3	8.7	8.1	7.4	6.7
14	.65	.30	.95	.60	.25	.90	.55	.20	.85	9.0	8.0	7.1	6.1	5.1
37 15	24.64	49.29	73.93	98.58	123.22	147.87	172.51	197.16	221.81	1478.7	2957.4	4436.1	5914.8	7393.4
16	.64	.28	.92	.56	.20	.84	.48	.12	.76	8.4	6.7	5.1	3.5	1.8
17	.63	.27	.90	.54	.17	.81	.44	.07	.71	8.1	6.1	4.1	2.2	90.2
18	.63	.26	.89	.51	.14	.77	.40	7.03	.66	7.7	5.4	3.2	10.8	88.6
19	.62	.25	.87	.49	.12	.74	.36	6.98	.61	7.4	4.8	2.2	09.5	6.9
37 20	24.62	49.24	73.85	98.47	123.09	147.71	172.32	196.94	221.56	1477.1	2954.1	4431.2	5908.2	7385.3
21	.61	.23	.84	.45	.06	.68	.29	.90	.51	6.8	3.5	30.2	6.9	3.7
22	.61	.21	.82	.43	.04	.64	.24	.85	.46	6.4	2.8	29.2	5.6	2.0
23	.60	.20	.80	.41	3.01	.61	.21	.81	.41	6.1	2.2	8.3	4.3	80.4
24	.60	.19	.79	.38	2.98	.58	.17	.77	.36	5.8	1.5	7.3	3.0	78.8
37 25	24.59	49.18	73.77	98.36	122.95	147.54	172.13	196.72	221.32	1475.4	2950.9	4426.3	5901.7	7377.1
26	.58	.17	.75	.34	.93	.51	.09	.68	.27	5.1	50.2	5.3	900.4	5.5
27	.58	.16	.74	.32	.90	.48	.06	.64	.22	4.8	49.6	4.3	899.1	3.9
28	.57	.15	.72	.30	.87	.44	2.02	.59	.17	4.4	8.9	3.4	7.8	2.2
29	.57	.14	.71	.28	.85	.41	1.98	.55	.12	4.1	8.3	2.4	6.5	70.6
37 30	24.56	49.13	73.69	98.25	122.82	147.38	171.94	196.51	221.07	1473.8	2947.6	4421.4	5895.2	7369.0
31	.56	.12	.67	.23	.79	.35	.91	.46	1.02	3.5	6.9	20.4	4.9	7.3
32	.55	.11	.66	.21	.76	.31	.86	.42	0.97	3.1	6.3	19.4	3.5	5.7
33	.55	.09	.64	.19	.74	.28	.83	.37	.92	2.8	5.6	8.4	2.2	4.0
34	.54	.08	.62	.17	.71	.25	.79	.33	.87	2.5	5.0	7.5	90.9	2.4
37 35	24.54	49.07	73.61	98.14	122.68	147.22	171.75	196.29	220.82	1472.2	2944.3	4416.5	5888.6	7360.8
36	.53	.06	.59	.12	.65	.18	.71	.24	.78	1.8	3.6	5.5	7.3	59.1
37	.53	.05	.58	.10	.62	.15	.67	.20	.73	1.5	3.0	4.5	6.0	7.5
38	.52	.04	.56	.08	.60	.12	.64	.16	.68	1.2	2.3	3.5	4.7	5.8
39	.51	.03	.54	.06	.57	.08	.60	.11	.63	0.8	1.7	2.5	3.4	4.2
37 40	24.51	49.02	73.53	98.03	122.54	147.05	171.56	196.07	220.58	1470.5	2941.0	4411.5	5882.0	7352.6
41	.50	.01	.51	8.01	.51	7.02	.52	6.02	.53	70.2	40.3	10.5	80.7	50.9
42	.50	9.00	.49	7.99	.49	6.99	.48	5.98	.48	69.9	39.7	09.5	79.4	49.3
43	.49	8.98	.48	.97	.46	.95	.45	.94	.43	9.5	9.0	8.6	8.1	7.6
44	.49	.97	.46	.95	.43	.92	.41	.89	.38	9.2	8.4	7.6	6.8	6.0
37 45	24.48	48.96	73.44	97.92	122.40	146.89	171.37	195.85	220.33	1468.9	2937.7	4406.6	5875.5	7344.3
46	.47	.95	.43	.90	.38	.85	.33	.80	.28	8.5	7.0	5.6	4.1	2.7
47	.47	.94	.41	.88	.35	.82	.29	.76	.23	8.2	6.4	4.6	2.8	41.0
48	.46	.93	.39	.86	.32	.79	.26	.72	.18	7.9	5.7	3.7	1.5	39.4
49	.46	.92	.38	.84	.30	.75	.21	.67	.13	7.5	5.1	2.7	70.2	7.7
37 50	24.45	48.91	73.36	97.81	122.27	146.72	171.17	195.63	220.08	1467.2	2934.4	4401.7	5868.9	7336.1
51	.45	.90	.34	.79	.24	.69	.14	.58	20.03	6.9	3.7	400.7	7.5	4.4
52	.44	.89	.33	.77	.21	.66	.10	.54	19.98	6.6	3.1	399.7	6.2	2.8
53	.44	.87	.31	.75	.19	.62	.06	.50	.93	6.2	2.4	8.7	4.9	31.1
54	.43	.86	.30	.73	.16	.59	1.02	.45	.88	5.9	1.8	7.7	3.6	29.5
37 55	24.43	48.85	73.28	97.70	122.13	146.56	170.98	195.41	219.83	1465.6	2931.1	4396.7	5862.3	7327.8
56	.42	.84	.26	.68	.10	.52	.94	.36	.79	5.2	30.5	5.7	60.9	6.2
57	.42	.83	.25	.66	.07	.49	.91	.32	.74	4.9	29.8	4.7	59.6	4.5
58	.41	.82	.23	.64	.05	.46	.87	.28	.69	4.6	9.1	3.7	8.3	2.9
59	.40	.81	.21	.62	2.02	.42	.83	.23	.64	4.2	8.5	2.7	7.0	21.2
37 60	24.40	48.80	73.20	97.59	121.99	146.39	170.79	195.19	219.59	1463.9	2927.8	4391.7	5855.6	7319.6

Lat.	Latitude 37° to 38°—Meridional arcs.						Latitude 37°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
37 00	30.826			1849.58					
1	6	1	30.83	.59	1	1 849.6	0 1	1 483.6	0.1
2	7	2	61.66	.59	2	3 699.2	2	2 967.1	0.5
3	7	3	92.49	.60	3	5 548.8	3	4 450.7	1.2
4	7	4	123.32	.61	4	7 398.4	4	5 934.2	2.1
37 05	30.827	5	154.15	1849.61	5	9 248.0	0 5	7 417.8	3.3
6	7	6	184.97	.62	6	11 097.6	6	8 901.4	4.7
7	7	7	215.80	.62	7	12 947.2	7	10 384.9	6.4
8	7	8	246.63	.63	8	14 796.8	8	11 868.5	8.3
9	7	9	277.46	.63	9	16 646.5	9	13 352.1	10.5
37 10	30.827	10	308.29	1849.64	10	18 496.1	0 10	14 835.6	13.0
11	7	1	339.12	.64	1	20 345.7	15	22 253.4	29.2
12	7	2	369.95	.65	2	22 195.4	20	29 671.2	51.9
13	8	3	400.78	.65	3	24 045.0	25	37 089.0	81.2
14	8	4	431.61	.66	4	25 894.7	30	44 506.7	116.9
37 15	30.828	15	462.44	1849.66	15	27 744.4	0 35	51 924.4	159.1
16	8	6	493.26	.67	6	29 594.0	40	59 342.1	207.8
17	8	7	524.09	.67	7	31 443.7	45	66 759.7	263.0
18	8	8	554.92	.68	8	33 293.4	50	74 177.2	324.6
19	8	9	585.75	.68	9	35 143.1	55	81 594.7	392.8
37 20	30.828	20	616.58	1849.69	20	36 992.7	1 00	89 012.2	467.5
21	8	1	647.41	.69	1	38 842.4	05	96 429.6	548.6
22	8	2	678.24	.70	2	40 692.1	10	103 846.9	636.3
23	8	3	709.07	.71	3	42 541.8	15	111 264.1	730.4
24	9	4	739.90	.71	4	44 391.5	20	118 681.2	831.1
37 25	30.829	25	770.73	1849.72	25	46 241.3	1 25	126 098.3	938.2
26	9	6	801.56	.72	6	48 091.0	30	133 515.2	1 051.8
27	9	7	832.38	.73	7	49 940.7	35	140 932.1	1 171.9
28	9	8	863.21	.73	8	51 790.4	40	148 348.8	1 298.5
29	9	9	894.04	.74	9	53 640.2	45	155 765.4	1 431.6
37 30	30.829	30	924.87	1849.74	30	55 489.9	1 50	163 181.9	1 571.2
31	9	1	955.70	.75	1	57 339.6	55	170 598.3	1 717.3
32	9	2	986.53	.75	2	59 189.4	2 00	178 015	1 870
33	9	3	1 017.36	.76	3	61 039.1	3 00	266 997	4 207
34	9	4	1 048.19	.76	4	62 888.9	4 00	355 951	7 479
37 35	30.829	35	1 079.02	1849.77	35	64 738.7	5 00	444 865	11 685
36	30	6	1 109.85	.77	6	66 588.4	6 00	533 730	16 824
37	0	7	1 140.67	.78	7	68 438.2	7 00	622 536	22 896
38	0	8	1 171.50	.78	8	70 288.0	8 00	711 273	29 901
39	0	9	1 202.33	.79	9	72 137.8	9 00	799 932	37 838
37 40	30.830	40	1 233.16	1849.80	40	73 987.6	10 00	888 503	46 706
41	0	1	1 263.99	.80	1	75 837.4	11 00	976 975	56 503
42	0	2	1 294.82	.81	2	77 687.2	12 00	1 065 340	67 229
43	0	3	1 325.65	.81	3	79 537.0	13 00	1 153 587	78 882
44	0	4	1 356.48	.82	4	81 386.8	14 00	1 241 707	91 462
37 45	30.830	45	1 387.31	1849.82	45	83 236.6	15 00	1 329 690	104 967
46	0	6	1 418.14	.83	6	85 086.5	16 00	1 417 526	119 395
47	1	7	1 448.96	.83	7	86 936.3	17 00	1 505 206	134 745
48	1	8	1 479.79	.84	8	88 786.1	18 00	1 592 721	151 015
49	1	9	1 510.62	.84	9	90 636.0	19 00	1 680 059	168 203
37 50	30.831	50	1 541.45	1849.85	50	92 485.8	20 00	1 767 211	186 307
51	1	1	1 572.28	.85	1	94 335.7	21 00	1 854 169	205 326
52	1	2	1 603.11	.86	2	96 185.5	22 00	1 940 922	225 258
53	1	3	1 633.94	.86	3	98 035.4	23 00	2 027 462	246 099
54	1	4	1 664.77	.87	4	99 885.2	24 00	2 113 777	267 849
37 55	30.831	55	1 695.60	1849.88	55	101 735.1	25 00	2 199 860	290 503
56	1	6	1 726.43	.88	6	103 585.0	26 00	2 285 699	314 061
57	1	7	1 757.26	.89	7	105 434.9	27 00	2 371 287	338 519
58	2	8	1 788.08	.89	8	107 284.8	28 00	2 456 612	363 874
59	2	9	1 818.91	.90	9	109 134.7	29 00	2 541 667	390 125
37 60	30.832	60	1 849.74	1849.90	60	110 984.5	30 00	2 626 441	417 267

Latitude 38° to 39°—Arcs of the parallel in meters.

Lat. ° ′	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
38 00	24.40	48.80	73.20	97.59	121.99	146.39	170.79	195.19	219.59	1463.9	2927.8	4391.7	5855.6	7319.6
1	.39	.79	.18	.57	.96	.36	.75	.15	.54	3.6	7.1	90.7	4.3	7.9
2	.39	.78	.16	.55	.94	.32	.71	.10	.49	3.2	6.5	89.7	3.0	6.2
3	.38	.77	.15	.53	.91	.29	.67	.06	.44	2.9	5.8	8.7	1.7	4.6
4	.38	.76	.13	.51	.88	.26	.63	5.01	.39	2.6	5.2	7.7	50.3	2.9
38 05	24.37	48.74	73.11	97.48	121.86	146.22	170.60	194.97	219.34	1462.3	2924.5	4386.7	5849.0	7311.3
6	.36	.73	.10	.46	.83	.19	.56	.93	.29	1.9	3.8	5.7	7.7	09.6
7	.36	.72	.08	.44	.80	.16	.52	.88	.24	1.6	3.2	4.7	6.3	7.9
8	.35	.71	.06	.42	.77	.13	.48	.84	.19	1.3	2.5	3.8	5.0	6.3
9	.35	.70	.05	.39	.75	.09	.44	.79	.14	0.9	1.9	82.8	3.7	4.6
38 10	24.34	48.69	73.03	97.37	121.72	146.06	170.40	194.75	219.09	1460.6	2921.2	4381.8	5842.4	7303.0
11	.34	.68	.01	.35	.69	6.03	.36	.71	9.04	60.3	20.5	80.8	41.0	301.3
12	.33	.67	3.00	.33	.66	5.99	.32	.66	8.99	59.9	19.8	79.8	39.7	299.6
13	.33	.66	2.98	.31	.64	.96	.29	.62	.94	9.6	9.2	8.8	8.4	8.0
14	.32	.65	.96	.29	.61	.93	.25	.57	.89	9.3	8.5	7.8	7.0	6.3
38 15	24.32	48.63	72.95	97.26	121.58	145.89	170.21	194.53	218.84	1458.9	2917.8	4376.8	5835.7	7294.6
16	.31	.62	.93	.24	.55	.86	.17	.48	.79	8.6	7.2	5.8	4.4	3.0
17	.31	.61	.91	.22	.52	.83	.13	.44	.74	8.3	6.5	4.8	3.0	91.3
18	.30	60	.90	.19	.50	.79	.09	.39	.69	7.9	5.8	3.8	1.7	89.6
19	.30	.59	.88	.17	.47	.76	.05	.35	.64	7.6	5.2	2.8	30.4	8.0
38 20	24.29	48.58	72.86	97.15	121.44	145.73	170.01	194.30	218.59	1457.3	2914.5	4371.8	5829.0	7286.3
21	.28	.57	.85	.13	.41	.69	69.97	.26	.54	6.9	3.8	70.8	7.7	4.6
22	.28	.56	.83	.11	.38	.66	.93	.21	.49	6.6	3.2	69.8	6.4	2.9
23	.27	.54	.81	.08	.36	.63	.89	.17	.44	6.3	2.5	8.8	5.0	81.3
24	.27	.53	.80	.06	.33	.59	.85	.12	.39	5.9	1.9	7.8	3.7	79.6
38 25	24.26	48.52	72.78	97.04	121.30	145.56	169.82	194.08	218.34	1455.6	2911.2	4366.8	5822.3	7277.9
26	.25	.51	.76	.02	.27	.53	.78	4.04	.29	5.3	10.5	5.8	21.0	6.3
27	.25	.50	.75	7.00	.24	.49	.74	3.99	.24	4.9	09.8	4.8	19.7	4.6
28	.24	.48	.73	6.97	.22	.46	.70	.95	.19	4.6	9.2	3.7	8.3	2.9
29	.24	.47	.71	.95	.19	.42	.66	.90	.14	4.2	8.5	2.7	7.0	71.2
38 30	24.23	48.46	72.70	96.93	121.16	145.39	169.62	193.86	218.09	1453.9	2907.8	4361.7	5815.7	7269.6
31	.23	.45	.68	.91	.13	.36	.58	.82	8.04	3.6	7.1	60.7	4.3	7.9
32	.22	.44	.66	.88	.10	.32	.54	.77	7.99	3.2	6.5	59.7	3.0	6.2
33	.22	.43	.65	.86	.08	.29	.50	.73	.94	2.9	5.8	8.7	1.6	4.5
34	.21	.42	.63	.84	.05	.26	.46	.68	.89	2.6	5.2	7.7	10.3	2.9
38 35	24.20	48.40	72.61	96.81	121.02	145.22	169.43	193.63	217.83	1452.2	2904.5	4356.7	5808.9	7261.2
36	.20	.39	.60	.79	0.99	.19	.39	.59	.78	1.9	3.8	5.7	7.6	59.5
37	.19	.38	.58	.77	.96	.16	.35	.55	.73	1.6	3.1	4.7	6.3	7.8
38	.19	.37	.56	.75	.94	.12	.31	.50	.68	1.2	2.5	3.7	4.9	6.1
39	.18	.36	.55	.73	.91	.09	.27	.45	.63	0.9	1.8	2.7	3.6	4.5
38 40	24.18	48.35	72.53	96.70	120.88	145.06	169.23	193.41	217.58	1450.6	2901.1	4351.7	5802.2	7252.8
41	.17	.34	.51	.68	.85	5.02	.19	.37	.53	0.2	900.4	50.7	800.9	51.1
42	.17	.33	.49	.66	.82	4.99	.15	.32	.48	49.9	899.7	49.7	799.5	49.4
43	.16	.32	.48	.64	.80	.96	.11	.28	.43	9.6	9.1	8.6	8.2	7.7
44	.16	.31	.46	.61	.77	.92	.07	.23	.38	9.2	8.4	7.6	6.8	6.1
38 45	24.15	48.29	72.44	96.59	120.74	144.89	169.04	193.19	217.33	1448.9	2897.7	4346.6	5795.5	7244.4
46	.14	.28	.43	.57	.71	.85	9.00	.14	.28	8.5	7.0	5.6	4.1	2.7
47	.14	.27	.41	.55	.68	.82	8.96	.10	.23	8.2	6.4	4.6	2.8	41.0
48	.13	.26	.39	.52	.66	.79	.92	.05	.18	7.9	5.7	3.6	1.5	39.3
49	.13	.25	.38	.50	.63	.75	.88	3.01	.13	7.5	5.1	2.6	90.1	7.6
38 50	24.12	48.24	72.36	96.48	120.60	144.72	168.84	192.96	217.08	1447.2	2894.4	4341.6	5788.8	7236.0
51	.11	.23	.34	.46	.57	.69	.80	.92	7.03	6.9	3.7	40.6	7.4	4.3
52	.11	.22	.33	.43	.54	.65	.76	.87	6.98	6.5	3.0	39.6	6.1	2.6
53	.10	.21	.31	.41	.52	.62	.72	.83	.93	6.2	2.4	8.5	4.7	30.9
54	.10	.20	.29	.39	49	.58	.68	.78	.88	5.8	1.7	7.5	3.3	29.2
38 55	24.09	48.18	72.28	96.36	120.46	144.55	168.64	192.74	216.82	1445.5	2891.0	4336.5	5782.0	7227.5
56	.08	.17	.26	.34	.43	.52	.60	.69	.77	5.2	90.3	5.5	80.6	5.8
57	.08	.16	.24	.32	.40	.48	.56	.65	.72	4.8	89.6	4.5	79.3	4.1
58	.07	.15	.22	.30	.38	.45	.52	.60	.67	4.5	9.0	3.4	7.9	2.4
59	.07	.14	.21	.28	.35	.41	.48	.56	.62	4.1	8.3	2.4	6.6	20.7
38 60	24.06	48.13	72.19	96.25	120.32	144.38	168.44	192.51	216.57	1443.8	2887.6	4331.4	5775.2	7219.0

Lat.	Latitude 38° to 39°—Meridional arcs.						Latitude 38°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
38 00	30.832			1849.90					
1	2	1	30.83	.91	1	1 849.9	0 1	1 463.9	0.1
2	2	2	61.67	.91	2	3 699.8	2	2 927.8	0.5
3	2	3	92.50	.92	3	5 549.7	3	4 391.7	1.2
4	2	4	123.34	.92	4	7 399.6	4	5 855.6	2.1
38 05	30.832	5	154.17	1849.93	5	9 249.6	0 5	7 319.6	3.3
6	2	6	185.01	.93	6	11 099.5	6	8 783.5	4.7
7	2	7	215.84	.94	7	12 949.4	7	10 247.4	6.4
8	2	8	246.67	.94	8	14 799.4	8	11 711.3	8.4
9	2	9	277.51	.95	9	16 649.3	9	13 175.2	10.6
38 10	30.833	10	308.34	1849.95	10	18 499.3	0 10	14 639.1	13.1
11	3	1	339.18	.96	1	20 349.2	15	21 958.6	29.5
12	3	2	370.01	.97	2	22 199.2	20	29 278.2	52.4
13	3	3	400.85	.97	3	24 049.2	25	36 597.6	81.9
14	3	4	431.68	.98	4	25 899.1	30	43 917.1	118.0
38 15	30.833	15	462.52	1849.98	15	27 749.1	0 35	51 236 5	160.6
16	3	6	493.35	.99	6	29 599.1	40	58 555.9	209.8
17	3	7	524.18	49.99	7	31 449.1	45	65 875.3	265.5
18	3	8	555.02	50.00	8	33 299.1	50	73 194.6	327.7
19	3	9	585.85	.00	9	35 149.1	55	80 513.8	396.5
38 20	30.833	20	616.69	1850.01	20	36 999.1	1 00	87 833.0	471.9
21	4	1	647.52	.01	1	38 849.1	05	95 152.1	553.8
22	4	2	678.36	.02	2	40 699.1	10	102 471.1	642.3
23	4	3	709.19	.02	3	42 549.1	15	109 790.0	737.3
24	4	4	740.02	.03	4	44 399.2	20	117 108.9	838.9
38 25	30.834	25	770.86	1850.03	25	46 249.2	1 25	124 427.6	947.1
26	4	6	801.69	.04	6	48 099.2	30	131 746.3	1 061.8
27	4	7	832.53	.05	7	49 949.3	35	139 064.8	1 183.0
28	4	8	863.36	.05	8	51 799.3	40	146 383.3	1 310.8
29	4	9	894.20	.06	9	53 649.4	45	153 701.6	1 445.2
38 30	30.834	30	925.03	1850.06	30	55 499.4	1 50	161 019.8	1 586.1
31	4	1	955.87	.07	1	57 349.5	55	168 337.9	1 733.5
32	5	2	986.70	.07	2	59 199.6	2 00	175 656	1 888
33	5	3	1 017.53	.08	3	61 049.7	3 00	263 458	4 247
34	5	4	1 048.37	.08	4	62 899.7	4 00	351 230	7 549
38 35	30.835	35	1 079.20	1850.09	35	64 749.8	5 00	438 962	11 795
36	5	6	1 110.04	.09	6	66 599.9	6 00	526 643	16 983
37	5	7	1 140.87	.10	7	68 450.0	7 00	614 263	23 112
38	5	8	1 171.71	.10	8	70 300.1	8 00	701 812	30 183
39	5	9	1 202.54	.11	9	72 150.2	9 00	789 280	38 195
38 40	30.835	40	1 233.37	1850.11	40	74 000.3	10 00	876 657	47 145
41	5	1	1 264.21	.12	1	75 850.4	11 00	963 933	57 034
42	5	2	1 295.04	.13	2	77 700.6	12 00	1 051 098	67 860
43	6	3	1 325.88	.13	3	79 550.7	13 00	1 138 141	79 622
44	6	4	1 356.71	.14	4	81 400.8	14 00	1 225 053	92 319
38 45	30.836	45	1 387.55	1850.14	45	83 251.0	15 00	1 311 823	105 949
46	6	6	1 418.38	.15	6	85 101.1	16 00	1 398 441	120 511
47	6	7	1 449.21	.15	7	86 951.3	17 00	1 484 899	136 002
48	6	8	1 480.05	.16	8	88 801.4	18 00	1 571 185	152 421
49	6	9	1 510.88	.16	9	90 651.6	19 00	1 657 289	169 767
38 50	30.836	50	1 541.72	1850.17	50	92 501.8	20 00	1 743 202	188 037
51	6	1	1 572.55	.17	1	94 351.9	21 00	1 828 914	207 229
52	6	2	1 603.39	.18	2	96 202.1	22 00	1 914 415	227 341
53	6	3	1 634.22	.18	3	98 052.3	23 00	1 999 694	248 370
54	6	4	1 665.06	.19	4	99 902.5	24 00	2 084 743	270 315
38 55	30.837	55	1 695.89	1850.20	55	101 752.7	25 00	2 169 551	293 172
56	7	6	1 726.72	.20	6	103 602.9	26 00	2 254 109	316 939
57	7	7	1 757.56	.21	7	105 453.1	27 00	2 338 406	341 613
58	7	8	1 788.39	.21	8	107 303.3	28 00	2 422 433	367 192
59	7	9	1 819.23	.22	9	109 153.5	29 00	2 506 181	393 672
38 60	30.837	60	1 850.06	1850.22	60	111 003.7	30 00	2 589 639	421 050

Latitude 39° to 40°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
39 00	24.06	48.13	72.19	96.25	120.32	144.38	168.44	192.51	216.57	1443.8	2887.6	4331.4	5775.2	7219.0
1	.06	.12	.17	.23	.29	.35	.40	.47	.52	3.5	6.9	30.4	3.9	7.4
2	.05	.11	.16	.21	.26	.31	.36	.42	.47	3.1	6.2	29.4	2.5	5.7
3	.05	.09	.14	.19	.23	.28	.32	.38	.42	2.8	5.6	8.4	71.2	4.0
4	.04	.08	.12	.16	.20	.25	.28	.33	.37	2.5	4.9	7.4	69.8	2.3
39 05	24.04	48.07	72.11	96.14	120.18	144.21	168.24	192.29	216.32	1442.1	2884.2	4326.3	5768.4	7210.6
6	.03	.06	.09	.12	.15	.18	.21	.24	.26	1.8	3.5	5.3	7.1	08.9
7	.03	.05	.07	.10	.12	.14	.17	.20	.21	1.4	2.8	4.3	5.7	7.2
8	.02	.03	.05	.07	.09	.11	.13	.15	.16	1.1	2.2	3.3	4.4	5.5
9	.01	.02	.04	.05	.06	.08	.09	.11	.11	0.8	1.5	2.3	3.0	3.8
39 10	24.01	48.01	72.02	96.03	120.03	144.04	168.05	192.06	216.06	1440.4	2880.8	4321.3	5761.7	7202.1
11	.00	8.00	2.00	6.01	20.01	4.01	8.01	2.01	6.01	40.1	80.1	20.2	60.3	200.4
12	4.00	7.99	1.99	5.98	19.97	3.97	7.97	1.97	5.96	39.7	79.4	19.2	58.9	198.7
13	3.99	.98	.97	.96	.95	.94	.93	.92	.91	9.4	8.8	8.2	7.6	7.0
14	.99	.97	.95	.94	.92	.91	.89	.88	.86	9.1	8.1	7.2	6.2	5.3
39 15	23.98	47.96	71.94	95.91	119.89	143.87	167.85	191.83	215.80	1438.7	2877.4	4316.1	5754.9	7193.6
16	.97	.94	.92	.89	.86	.84	.81	.78	.75	8.4	6.7	5.1	3.5	1.9
17	.97	.93	.90	.87	.83	.80	.77	.74	.70	8.0	6.0	4.1	2.1	90.2
18	.96	.92	.88	.85	.81	.77	.73	.69	.65	7.7	5.4	3.1	50.8	88.5
19	.96	.91	.87	.82	.78	.74	.69	.65	.60	7.4	4.7	2.0	49.4	6.8
39 20	23.95	47.90	71.85	95.80	119.75	143.70	167.65	191.60	215.55	1437.0	2874.0	4311.0	5748.0	7185.1
21	.94	.89	.83	.78	.72	.67	.61	.56	.50	6.7	3.3	10.0	6.7	3.3
22	.94	.88	.82	.75	.69	.63	.57	.51	.45	6.3	2.6	09.0	5.3	81.6
23	.93	.87	.80	.73	.67	.60	.53	.47	.40	6.0	2.0	8.0	3.9	79.9
24	.93	.86	.78	.71	.64	.56	.49	.42	.35	5.6	1.3	6.9	2.6	8.2
39 25	23.92	47.84	71.77	95.69	119.61	143.53	167.45	191.38	215.29	1435.3	2870.6	4305.9	5741.2	7176.5
26	.91	.83	.75	.66	.58	.50	.41	.33	.24	5.0	69.9	4.9	39.8	4.8
27	.91	.82	.73	.64	.55	.46	.37	.29	.19	4.6	9.2	3.9	8.5	3.1
28	.90	.81	.71	.62	.53	.43	.33	.24	.14	4.3	8.6	2.8	7.1	71.4
29	.90	.80	.70	.60	.50	.39	.29	.20	.09	3.9	7.9	1.8	5.7	69.7
39 30	23.89	47.79	71.68	95.57	119.47	143.36	167.25	191.15	215.04	1433.6	2867.2	4300.8	5734.4	7168.0
31	.89	.78	.66	.55	.44	.33	.21	.10	4.99	3.3	6.5	299.8	3.0	6.3
32	.88	.77	.65	.53	.41	.29	.17	.06	.94	2.9	5.8	8.7	1.6	4.5
33	.88	.75	.63	.50	.38	.26	.13	1.01	.88	2.6	5.2	7.7	30.3	2.8
34	.87	.74	.61	.48	.35	.22	.09	0.97	.83	2.2	4.5	6.7	28.9	61.1
39 35	23.87	47.73	71.59	95.46	119.33	143.19	167.05	190.92	214.78	1431.9	2863.8	4295.6	5727.5	7159.4
36	.86	.72	.58	.44	.30	.16	7.01	.87	.73	1.6	3.1	4.6	6.1	7.7
37	.86	.71	.56	.42	.27	.12	6.97	.83	.68	1.2	2.4	3.6	4.8	6.0
38	.85	.69	.54	.39	.24	.09	.93	.78	.62	0.9	1.7	2.5	3.4	4.2
39	.84	.68	.53	.37	.21	.05	.89	.74	.57	0.5	1.0	1.5	2.0	2.5
39 40	23.84	47.67	71.51	95.35	119.18	143.02	166.85	190.69	214.52	1430.2	2860.3	4290.5	5720.7	7150.8
41	.83	.66	.49	.32	15	2.98	.81	.64	.47	29.8	59.6	89.5	19.3	49.1
42	.83	.65	.47	.30	.12	.95	.77	.60	.42	9.5	8.9	8.4	7.9	7.4
43	.82	.64	.46	.28	.09	.91	.73	.55	.37	9.1	8.3	7.4	6.5	5.6
44	.82	.63	.44	.25	.06	.88	.69	.51	.32	8.8	7.6	6.4	5.1	3.9
39 45	23.81	47.61	71.42	95.23	119.03	142.84	166.65	190.46	214.26	1428.4	2856.9	4285.3	5713.8	7142.2
46	.80	.60	.41	.21	9.01	.81	.61	.41	.21	8.1	6.2	4.3	2.4	40.5
47	.80	.59	.39	.18	8.98	.78	.57	.37	.16	7.8	5.5	3.3	11.0	38.8
48	.79	.58	.37	.16	.95	.74	.53	.32	.11	7.4	4.8	2.2	09.6	7.0
49	.79	.57	.35	.14	.92	.71	.49	.28	.06	7.1	4.1	1.2	8.3	5.3
39 50	23.78	47.56	71.34	95.11	118.89	142.67	166.45	190.23	214.01	1426.7	2853.4	4280.2	5706.9	7133.6
51	.77	.55	.32	.09	.86	.64	.41	.18	3.96	6.4	2.7	79.1	5.5	1.9
52	.77	.53	.30	.07	.83	.60	.37	.14	.91	6.0	2.0	8.1	4.1	30.1
53	.76	.52	.28	.04	.81	.57	.33	.09	.85	5.7	1.4	7.1	2.7	28.4
54	.76	.51	.27	5.02	.78	.53	.29	.05	.80	5.3	0.7	6.0	1.4	6.7
39 55	23.75	47.50	71.25	94.99	118.75	142.50	166.25	190.00	213.75	1425.0	2850.0	4275.0	5700.0	7125.0
56	.74	.49	.23	.97	.72	.47	.21	89.95	.70	4.7	49.3	3.9	698.6	3.2
57	.74	.48	.21	.95	.69	.43	.17	.91	.65	4.3	8.6	2.9	7.2	21.5
58	.73	.46	.20	.93	.67	.40	.13	.86	.59	4.0	7.9	1.9	5.8	19.8
59	.73	.45	.18	.90	.63	.36	.09	.81	.54	3.6	7.2	70.8	4.4	8.1
39 60	23.72	47.44	71.16	94.88	118.61	142.33	166.05	189.77	213.49	1423.3	2846.5	4269.8	5693.1	7116.3

Lat.		Latitude 39° to 40°—Meridional arcs.						Latitude 39°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
39	00	30.837			1850.22						
	1	7	1	30.84	.23	1	1 850.2	0	1	1 443.8	0.1
	2	7	2	61.68	.23	2	3 700.5		2	2 887.6	0.5
	3	7	3	92.52	.24	3	5 550.7		3	4 331.4	1.2
	4	7	4	123.36	.24	4	7 400.9		4	5 775.2	2.1
39	05	30.837	5	154.20	1850.25	5	9 251.2	0	5	7 219.0	3.3
	6	8	6	185.04	.25	6	11 101.4		6	8 662.9	4.8
	7	8	7	215.88	.26	7	12 951.7		7	10 106.7	6.5
	8	8	8	246.72	.26	8	14 801.9		8	11 550.5	8.5
	9	8	9	277.56	.27	9	16 652.2		9	12 994.3	10.7
39	10	30.838	10	308.40	1850.28	10	18 502.5	0	10	14 438.1	13.2
	11	8	1	339.24	.28	1	20 352.8		15	21 657.1	29.7
	12	8	2	370.08	.29	2	22 203.0		20	28 876.1	52.9
	13	8	3	400.92	.29	3	24 053.3		25	36 095.1	82.6
	14	8	4	431.76	.30	4	25 903.6		30	43 314.1	118.9
39	15	30.838	15	462.60	1850.30	15	27 753.9	0	35	50 533.0	161.9
	16	8	6	493.44	.31	6	29 604.2		40	57 751.9	211.5
	17	9	7	524.28	.31	7	31 454.5		45	64 970.7	267.6
	18	9	8	555.11	.32	8	33 304.9		50	72 189.5	330.4
	19	9	9	585.95	.32	9	35 155.2		55	79 408.2	399.8
39	20	30.839	20	616.79	1850.33	20	37 005.5	1	00	86 626.9	475.8
	21	9	1	647.63	.33	1	38 855.8		05	93 845.4	558.4
	22	9	2	678.47	.34	2	40 706.2		10	101 063.9	647.6
	23	9	3	709.31	.35	3	42 556.5		15	108 282.4	743.4
	24	9	4	740.15	.35	4	44 406.9		20	115 500.7	845.8
39	25	30.839	25	770.99	1850.36	25	46 257.2	1	25	122 718.9	954.8
	26	9	6	801.83	.36	6	48 107.6		30	129 937.1	1 070.4
	27	9	7	832.67	.37	7	49 957.9		35	137 155.1	1 192.6
	28	40	8	863.51	.37	8	51 808.3		40	144 373.0	1 321.4
	29	0	9	894.35	.38	9	53 658.7		45	151 590.8	1 456.8
39	30	30.840	30	925.19	1850.38	30	55 509.1	1	50	158 808.4	1 598.8
	31	0	1	956.03	.39	1	57 359.4		55	166 025.9	1 747.5
	32	0	2	986.87	.39	2	59 209.8	2	00	173 243	1 903
	33	0	3	1 017.71	.40	3	61 060.2	3	00	259 839.	4 281
	34	0	4	1 048.55	.40	4	62 910.6	4	00	346 403	7 611
39	35	30.840	35	1 079.39	1850.41	35	64 761.0	5	00	432 925	11 891
	36	0	6	1 110.23	.42	6	66 611.4	6	00	519 396	17 121
	37	0	7	1 141.07	.42	7	68 461.9	7	00	605 803	23 300
	38	0	8	1 171.91	.43	8	70 312.3	8	00	692 138	30 428
	39	1	9	1 202.75	.43	9	72 162.7	9	00	778 388	38 504
39	40	30.841	40	1 233.59	1850.44	40	74 013.2	10	00	864 545	47 527
	41	1	1	1 264.43	.44	1	75 863.6	11	00	950 598	57 496
	42	1	2	1 295.27	.45	2	77 714.0	12	00	1 036 536	68 409
	43	1	3	1 326.11	.45	3	79 564.5	13	00	1 122 349	80 266
	44	1	4	1 356.95	.46	4	81 414.9	14	00	1 208 027	93 064
39	45	30.841	45	1 387.79	1850.46	45	83 265.4	15	00	1 293 559	106 802
	46	1	6	1 418.63	.47	6	85 115.9	16	00	1 378 934	121 479
	47	1	7	1 449.47	.47	7	86 966.3	17	00	1 464 144	137 093
	48	1	8	1 480.31	.48	8	88 816.8	18	00	1 549 177	153 642
	49	1	9	1 511.15	.49	9	90 667.3	19	00	1 634 023	171 124
39	50	30.842	50	1 541.99	1850.49	50	92 517.8	20	00	1 718 671	189 537
	51	2	1	1 572.83	.50	1	94 368.3	21	00	1 803 113	208 878
	52	2	2	1 603.67	.50	2	96 218.8	22	00	1 887 337	229 146
	53	2	3	1 634.50	.51	3	98 069.3	23	00	1 971 333	250 337
	54	2	4	1 665.34	.51	4	99 919.8	24	00	2 055 091	272 450
39	55	30.842	55	1 696.18	1850.52	55	101 770.3	25	00	2 138 602	295 481
	56	2	6	1 727.02	.52	6	103 620.8	26	00	2 221 854	319 429
	57	2	7	1 757.86	.53	7	105 471.4	27	00	2 304 838	344 289
	58	2	8	1 788.70	.53	8	107 321.9	28	00	2 387 545	370 059
	59	2	9	1 819.54	.54	9	109 172.4	29	00	2 469 963	396 736
39	60	30.842	60	1 850.38	1850.54	60	111 023.0	30	00	2 552 084	424 317

Latitude 40° to 41°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
40 00	23.72	47.44	71.16	94.88	118.61	142.33	166.05	189.77	213.49	1423.3	2846.5	4269.8	5693.1	7116.3
1	.72	.43	.15	.86	.58	.29	6.01	.72	.44	2.9	5.8	8.8	1.7	4.6
2	.71	.42	.13	.84	.55	.26	5.97	.68	.39	2.6	5.1	7.7	90.3	2.9
3	.70	.41	.11	.82	.52	.22	.93	.63	.33	2.2	4.5	6.7	88.9	11.1
4	.70	.40	.09	.79	.49	.19	.89	.58	.28	1.9	3.8	5.6	7.5	09.4
40 05	23.69	47.38	71.08	94.77	118.46	142.15	165.84	189.54	213.23	1421.5	2843.1	4264.6	5686.1	7107.7
6	.69	.37	.06	.75	.44	.12	.80	.49	.18	1.2	2.4	3.6	4.7	5.9
7	.68	.36	.04	.72	.41	.08	.76	.45	.13	0.8	1.7	2.5	3.4	4.2
8	.67	.35	.02	.70	.38	.05	.72	.40	.07	0.5	1.0	1.5	2.0	2.5
9	.67	.34	1.01	.68	.35	2.01	.68	.35	3.02	20.1	40.3	60.4	80.6	100.7
40 10	23.66	47.33	70.99	94.65	118.32	141.98	165.64	189.31	212.97	1419.8	2839.6	4259.4	5679.2	7099.0
11	.66	.32	.97	.63	.29	.95	.60	.26	.92	9.5	8.9	8.4	7.8	7.3
12	.65	.30	.96	.61	.26	.91	.56	.21	.87	9.1	8.2	7.3	6.4	5.5
13	.65	.29	.94	.58	.23	.88	.52	.17	.81	8.8	7.5	6.3	5.0	3.8
14	.64	.28	.92	.56	.20	.84	.48	.12	.76	8.4	6.8	5.2	3.6	2.0
40 15	23.63	47.27	70.90	94.54	118.18	141.81	165.44	189.07	212.71	1418.1	2836.1	4254.2	5672.2	7090.3
16	.63	.26	.89	.51	.15	.77	.40	9.03	.66	7.7	5.4	3.1	70.9	88.6
17	.62	.25	.87	.49	.12	.74	.36	8.98	.61	7.4	4.7	2.1	69.5	6.8
18	.62	.23	.85	.47	.09	.70	.32	.94	.55	7.0	4.0	1.1	8.1	5.1
19	.61	.22	.83	.44	.06	.67	.28	.89	.50	6.7	3.3	50.0	6.7	3.4
40 20	23.61	47.21	70.82	94.42	118.03	141.63	165.24	188.84	212.45	1416.3	2832.6	4249.0	5665.3	7081.6
21	.60	.20	.80	.40	8.00	.60	.20	.80	.40	6.0	1.9	7.9	3.9	79.9
22	.59	.19	.78	.37	7.97	.56	.16	.75	.34	5.6	1.2	6.9	2.5	8.1
23	.59	.18	.76	.35	.94	.53	.12	.70	.29	5.3	30.6	5.8	61.1	6.4
24	.58	.16	.75	.33	.91	.49	.08	.66	.24	4.9	29.9	4.8	59.7	4.6
40 25	23.58	47.15	70.73	94.31	117.89	141.46	165.03	188.61	212.18	1414.6	2829.2	4243.7	5658.3	7072.9
26	.57	.14	.71	.28	.85	.42	4.99	.56	.13	4.2	8.5	2.7	6.9	71.1
27	.56	.13	.69	.26	.83	.39	.95	.52	.08	3.9	7.8	1.6	5.5	69.4
28	.56	.12	.68	.24	.80	.35	.91	.47	2.03	3.5	7.1	40.6	4.1	7.7
29	.55	.10	.66	.21	.77	.32	.87	.42	1.97	3.2	6.4	39.5	2.7	5.9
40 30	23.55	47.09	70.64	94.19	117.74	141.28	164.83	188.38	211.92	1412.8	2825.7	4238.5	5651.3	7064.2
31	.54	.08	.62	.17	.71	.25	.79	.33	.87	2.5	5.0	7.4	49.9	2.4
32	.54	.07	.61	.14	.68	.21	.75	.28	.82	2.1	4.3	6.4	8.5	60.7
33	.53	.06	.59	.12	.65	.18	.71	.24	.76	1.8	3.6	5.3	7.1	58.9
34	.52	.05	.57	.10	.62	.14	.67	.19	.71	1.4	2.9	4.3	5.7	7.2
40 35	23.52	47.04	70.55	94.07	117.59	141.11	164.63	188.14	211.66	1411.1	2822.2	4233.2	5644.3	7055.4
36	.51	.02	.54	.05	.56	.07	.58	.10	.61	0.7	1.5	2.2	2.9	3.7
37	.51	.01	.52	.03	.53	.04	.54	.05	.56	0.4	0.8	1.1	1.5	1.9
38	.50	7.00	.50	4.00	.50	1.00	.50	8.00	.50	10.0	20.1	30.1	40.1	50.2
39	.49	6.99	.48	3.98	.47	0.97	.46	7.96	.45	09.7	19.4	29.0	38.7	48.4
40 40	23.49	46.98	70.47	93.96	117.44	140.93	164.42	187.91	211.40	1409.3	2818.7	4228.0	5637.3	7046.7
41	.48	.97	.45	.93	.41	.90	.38	.86	.35	9.0	8.0	6.9	5.9	4.9
42	.48	.95	.43	.91	.38	.86	.34	.82	.29	8.6	7.3	5.9	4.5	3.1
43	.47	.94	.41	.88	.35	.83	.30	.77	.24	8.3	6.5	4.8	3.1	41.4
44	.47	.93	.40	.86	.32	.79	.26	.72	.19	7.9	5.8	3.8	1.7	39.6
40 45	23.46	46.92	70.38	93.84	117.30	140.76	164.22	187.68	211.13	1407.6	2815.1	4222.7	5630.3	7037.9
46	.45	.91	.36	.81	.27	.72	.17	.63	.08	7.2	4.4	1.7	28.9	6.1
47	.45	.90	.34	.79	.24	.69	.13	.58	1.03	6.9	3.7	20.6	7.5	4.4
48	.44	.88	.33	.77	.21	.65	.09	.54	0.98	6.5	3.0	19.6	6.1	2.6
49	.44	.87	.31	.74	.18	.62	.05	.49	.92	6.2	2.3	8.5	4.7	30.8
40 50	23.43	46.86	70.29	93.72	117.15	140.58	164.01	187.44	210.87	1405.8	2811.6	4217.5	5623.3	7029.1
51	.42	.85	.27	.70	.12	.55	3.97	.40	.82	5.5	0.9	6.4	1.9	7.3
52	.42	.84	.26	.67	.09	.51	.93	.35	.77	5.1	10.2	5.3	20.4	5.6
53	.41	.83	.24	.65	.06	.48	.89	.30	.71	4.8	09.5	4.3	19.0	3.8
54	.41	.81	.22	.63	.03	.44	.85	.25	.66	4.4	8.8	3.2	7.6	2.0
40 55	23.40	46.80	70.20	93.60	117.01	140.41	163.81	187.21	210.61	1404.1	2808.1	4212.2	5616.2	7020.3
56	.39	.79	.18	.58	6.98	.37	.76	.16	.55	3.7	7.4	1.1	4.8	18.5
57	.39	.78	.17	.56	.95	.33	.72	.11	.50	3.3	6.7	10.0	3.4	6.7
58	.38	.77	.15	.53	.92	.30	.68	.07	.45	3.0	6.0	09.0	2.0	5.0
59	.38	.75	.13	.51	.89	.26	.64	7.02	.39	2.6	5.3	7.9	10.6	3.2
40 60	23.37	46.74	70.11	93.49	116.86	140.23	163.60	186.97	210.34	1402.3	2804.6	4206.9	5609.2	7011.5

Lat.		Latitude 40° to 41°—Meridional arcs.						Latitude 40°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
40	00	30.842			1850.54		–				
	1	2	1	30.85	.55	1	1 850.5	0	1	1 423.3	0.1
	2	3	2	61.69	.56	2	3 701.1		2	2 846.5	0.5
	3	3	3	92.54	.56	3	5 551.7		3	4 269.8	1.2
	4	3	4	123.38	.57	4	7 402.2		4	5 693.0	2.1
40	05	30.843	5	154.13	1850.57	5	9 252.8	0	5	7 116.3	3.3
	6	3	6	185.07	.58	6	11 103.4		6	8 539.6	4.8
	7	3	7	215.92	.58	7	12 953.9		7	9 962.8	6.5
	8	3	8	246.76	.59	8	14 804.5		8	11 386.1	8.5
	9	3	9	277.61	.59	9	16 655.1		9	12 809.3	10.8
40	10	30.843	10	308.45	1850.60	10	18 505.7	0	10	14 232.6	13.3
	11	3	1	339.30	.60	1	20 356.3		15	21 349.0	29.9
	12	3	2	370.14	.61	2	22 206.9		20	28 465.3	53.2
	13	4	3	400.99	.61	3	24 057.5		25	35 581.6	83.2
	14	4	4	431.83	.62	4	25 908.2		30	42 697.8	119.8
40	15	30.844	15	462.68	1850.63	15	27 758.8	0	35	49 814.0	163.0
	16	4	6	493.52	.63	6	29 609.4		40	56 930.2	212.9
	17	4	7	524.37	.64	7	31 460.0		45	64 046.3	269.4
	18	4	8	555.21	.64	8	33 310.7		50	71 162.4	332.6
	19	4	9	586.06	.65	9	35 161.3		55	78 278.4	402.5
40	20	30.844	20	616.90	1850.65	20	37 012.0	1	00	85 394.3	479.0
	21	4	1	647.75	.66	1	38 862.6		05	92 510.1	562.2
	22	4	2	678.59	.66	2	40 713.3		10	99 625.9	652.0
	23	4	3	709.44	.67	3	42 564.0		15	106 741.6	748.5
	24	5	4	740.28	.67	4	44 414.6		20	113 857.2	851.6
40	25	30.845	25	771.13	1850.68	25	46 265.3	1	25	120 972.7	961.4
	26	5	6	801.97	.68	6	48 116.0		30	128 088.1	1 077.8
	27	5	7	832.82	.69	7	49 966.7		35	135 203.4	1 200.8
	28	5	8	863.66	.70	8	51 817.4		40	142 318.5	1 330.5
	29	5	9	894.51	.70	9	53 668.1		45	149 433.6	1 466.9
40	30	30.845	30	925.35	1850.71	30	55 518.8	1	50	156 548.5	1 609.9
	31	5	1	956.20	.71	1	57 369.5		55	163 663.3	1 759.6
	32	5	2	987.04	.72	2	59 220.2	2	00	170 778	1 916
	33	5	3	1 017.89	.72	3	61 070.9	3	00	256 140	4 311
	34	5	4	1 048.73	.73	4	62 921.6	4	00	341 470	7 663
40	35	30.846	35	1 079.58	1850.73	35	64 772.4	5	00	426 757	11 972
	36	6	6	1 110.42	.74	6	66 623.1	6	00	511 990	17 238
	37	6	7	1 141.27	.74	7	68 473.8	7	00	597 158	23 460
	38	6	8	1 172.11	.75	8	70 324.6	8	00	682 252	30 637
	39	6	9	1 202.96	.76	9	72 175.3	9	00	767 260	38 768
40	40	30.846	40	1 233.80	1850.76	40	74 026.1	10	00	852 171	47 852
	41	6	1	1 264.65	.77	1	75 876.9	11	00	936 975	57 888
	42	6	2	1 295.49	.77	2	77 727.6	12	00	1 021 661	68 875
	43	6	3	1 326.34	.78	3	79 578.4	13	00	1 106 218	80 811
	44	6	4	1 357.18	.78	4	81 429.2	14	00	1 190 636	93 695
40	45	30.846	45	1 388.03	1850.79	45	83 280.0	15	00	1 274 904	107 525
	46	7	6	1 418.88	.79	6	85 130.8	16	00	1 359 012	122 300
	47	7	7	1 449.72	.80	7	86 981.6	17	00	1 442 949	138 017
	48	7	8	1 480.57	.80	8	88 832.4	18	00	1 526 704	154 675
	49	7	9	1 511.41	.81	9	90 683.2	19	00	1 610 267	172 272
40	50	30.847	50	1 542.26	1850.81	50	92 534.0	20	00	1 693 628	190 805
	51	7	1	1 573.10	.82	1	94 384.8	21	00	1 776 775	210 272
	52	7	2	1 603.95	.83	2	96 235.6	22	00	1 859 698	230 671
	53	7	3	1 634.79	.83	3	98 086.5	23	00	1 942 387	251 998
	54	7	4	1 665.64	.84	4	99 937.3	24	00	2 024 833	274 252
40	55	30.847	55	1 696.48	1850.84	55	101 788.1	25	00	2 107 023	297 430
	56	7	6	1 727.33	.85	6	103 639.0	26	00	2 188 948	321 528
	57	8	7	1 758.17	.85	7	105 489.8	27	00	2 270 597	346 543
	58	8	8	1 789.02	.86	8	107 340.7	28	00	2 351 961	372 473
	59	8	9	1 819.86	.86	9	109 191.5	29	00	2 433 029	399 314
40	60	30.848	60	1 850.71	1850.87	60	111 042.4	30	00	2 513 790	427 063

Latitude 41° to 42°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
41 00	23.37	46.74	70.11	93.49	116.86	140.23	163.60	186.97	210.34	1402.3	2804.6	4206.9	5609.2	7011.5
1	.37	.73	.10	.46	.83	.19	.56	.92	.29	1.9	3.9	5.8	7.7	009.7
2	.36	.72	.08	.44	.80	.16	.52	.88	.23	1.6	3.2	4.7	6.3	7.9
3	.35	.71	.06	.41	.77	.12	.48	.83	.18	1.2	2.4	3.7	4.9	6.1
4	.35	.70	.04	.39	.74	.09	.44	.78	.13	0.9	1.7	2.6	3.5	4.4
41 05	23.34	46.68	70.03	93.37	116.71	140.05	163.39	186.74	210.08	1400.5	2801.0	4201.6	5602.1	7002.6
6	.34	.67	70.01	.34	.68	40.02	.35	.69	10.02	400.2	800.3	200.5	600.7	7000.8
7	.33	.66	69.99	.32	.65	39.98	.31	.64	09.97	399.8	799.6	199.4	599.2	6999.1
8	.32	.65	.97	.30	.62	.95	.27	.59	.92	9.5	8.9	8.4	7.8	7.3
9	.32	.64	.96	.27	.59	.91	.23	.55	.86	9.1	8.2	7.3	6.4	5.5
41 10	23.31	46.63	69.94	93.25	116.56	139.88	163.19	186.50	209.81	1398.8	2797.5	4196.3	5595.0	6993.8
11	.31	.61	.92	.23	.53	.84	.15	.45	.76	8.4	6.8	5.2	3.6	2.0
12	.30	.60	.90	.20	.50	.80	.11	.41	.71	8.0	6.1	4.1	2.2	90.2
13	.29	.59	.88	.18	.47	.77	.06	.36	.65	7.7	5.4	3.1	90.7	88.4
14	.29	.58	.87	.16	.44	.73	3.02	.31	.60	7.3	4.7	2.0	89.3	6.7
41 15	23.28	46.57	69.85	93.13	116.42	139.70	162.98	186.26	209.54	1397.0	2794.0	4190.9	5587.9	6984.9
16	.28	.55	.83	.11	.39	.66	.94	.22	.49	6.6	3.3	89.9	6.5	3.1
17	.27	.54	.81	.08	.36	.63	.90	.17	.44	6.3	2.5	8.8	5.0	81.3
18	.27	.53	.80	.06	.33	.59	.86	.12	.39	5.9	1.8	7.7	3.6	79.6
19	.26	.52	.78	.04	.30	.56	.81	.07	.33	5.6	1.1	6.7	2.2	7.8
41 20	23.25	46.51	69.76	93.01	116.27	139.52	162.77	186.03	209.28	1395.2	2790.4	4185.6	5580.8	6976.0
21	.25	.49	.74	2.99	.23	.48	.72	5.97	.22	4.8	89.7	4.5	79.4	4.2
22	.24	.48	.72	.97	.21	.45	.69	.93	.17	4.5	9.0	3.5	8.0	2.4
23	.24	.47	.71	.94	.18	.41	.65	.88	.12	4.1	8.2	2.4	6.5	70.7
24	.23	.46	.69	.92	.15	.38	.61	.84	.07	3.8	7.5	1.3	5.1	68.9
41 25	23.22	46.45	69.67	92.89	116.12	139.34	162.56	185.79	209.01	1393.4	2786.8	4180.3	5573.7	6967.1
26	.22	.44	.65	.87	.09	.31	.52	.74	8.96	3.1	6.1	79.2	2.3	5.3
27	.21	.42	.63	.85	.06	.27	.48	.69	.91	2.7	5.4	8.1	70.8	3.5
28	.21	.41	.62	.82	.03	.24	.44	.65	.85	2.4	4.7	7.1	69.4	1.8
29	.20	.40	.60	.80	6.00	.20	.40	.60	.80	2.0	4.0	6.0	8.0	60.0
41 30	23.19	46.39	69.58	92.78	115.97	139.16	162.36	185.55	208.75	1391.6	2783.3	4174.9	5566.6	6958.2
31	.19	.38	.56	.75	.94	.13	.32	.50	.69	1.3	2.6	3.8	5.1	6.4
32	.18	.36	.55	.73	.91	.09	.28	.46	.64	0.9	1.9	2.8	3.7	4.6
33	.18	.35	.53	.70	.88	.06	.23	.41	.58	0.6	1.1	1.7	2.3	2.8
34	.17	.34	.51	.68	.85	9.02	.19	.36	.53	90.2	80.4	70.7	60.8	51.1
41 35	23.16	46.33	69.49	92.66	115.82	138.99	162.15	185.31	208.48	1389.9	2779.7	4169.6	5559.4	6949.3
36	.16	.32	.47	.63	.79	.95	.11	.27	.43	9.5	9.0	8.5	8.0	7.5
37	.15	.30	.46	.61	.76	.91	.07	.22	.37	9.1	8.3	7.4	6.6	5.7
38	.15	.29	.44	.59	.73	.88	2.02	.17	.32	8.8	7.5	6.3	5.1	3.9
39	.14	.28	.42	.56	.70	.84	1.98	.12	.26	8.4	6.8	5.3	3.7	2.1
41 40	23.13	46.27	69.40	92.54	115.67	138.81	161.94	185.08	208.21	1388.1	2776.1	4164.2	5552.3	6940.3
41	.13	.26	.38	.51	.64	.77	.90	5.03	.16	7.7	5.4	3.1	50.8	38.5
42	.12	.24	.37	.49	.61	.73	.86	4.98	.10	7.3	4.7	2.0	49.4	6.7
43	.12	.23	.35	.47	.58	.70	.82	.93	8.05	7.0	4.0	61.0	8.0	5.0
44	.11	.22	.33	.44	.55	.66	.77	.88	7.99	6.6	3.2	59.9	6.5	3.2
41 45	23.10	46.21	69.31	92.42	115.52	138.63	161.73	184.84	207.94	1386.3	2772.5	4158.8	5545.1	6931.4
46	.10	.20	.30	.39	.49	.59	.69	.79	.89	5.9	1.8	7.7	3.7	29.6
47	.09	.19	.28	.37	.46	.56	.65	.74	.83	5.6	1.1	6.7	2.2	7.8
48	.09	.17	.26	.35	.43	.52	.61	.69	.78	5.2	70.4	5.6	40.8	6.0
49	.08	.16	.24	.32	.40	.48	.56	.65	.72	4.8	69.7	4.5	39.4	4.2
41 50	23.07	46.15	69.22	92.30	115.37	138.45	161.52	184.60	207.67	1384.5	2769.0	4153.4	5537.9	6922.4
51	.07	.14	.21	.27	.34	.41	.48	.55	.62	4.1	8.3	2.4	6.5	20.6
52	.06	.13	.19	.25	.31	.38	.44	.50	.56	3.8	7.5	1.3	5.0	18.8
53	.06	.11	.17	.23	.28	.34	.40	.45	.51	3.4	6.8	50.2	3.6	7.0
54	.05	.10	.15	.20	.25	.30	.35	.41	.45	3.0	6.1	49.1	2.2	5.2
41 55	23.04	46.09	69.13	92.18	115.22	138.27	161.31	184.36	207.40	1382.7	2765.4	4148.0	5530.7	6913.4
56	.04	.08	.12	.16	.19	.23	.27	.31	.35	2.3	4.7	7.0	29.3	11.6
57	.03	.07	.10	.13	.16	.20	.23	.26	.29	2.0	3.9	5.9	7.8	09.8
58	.03	.05	.08	.11	.13	.16	.19	.21	.24	1.6	3.2	4.8	6.4	8.0
59	.02	.04	.06	.08	.10	.12	.14	.17	.18	1.2	2.5	3.7	5.0	6.2
41 60	23.01	46.03	69.04	92.06	115.07	138.09	161.10	184.12	207.13	1380.9	2761.8	4142.7	5523.5	6904.4

Lat.	Latitude 41° to 42°—Meridional arcs.						Latitude 41°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
41 00	30.848			1850.87					
1	8	1	30.85	.87	1	1 850.9	0 1	1 402.3	0.1
2	8	2	61.70	.88	2	3 701.7	2	2 804.6	0.5
3	8	3	92.55	.89	3	5 552.6	3	4 206.9	1.2
4	8	4	123.40	.89	4	7 403.5	4	5 609.2	2.1
41 05	30.848	5	154.25	1850.90	5	9 254.4	0 5	7 011.5	3.3
6	8	6	185.10	.90	6	11 105.3	6	8 413.7	4.8
7	8	7	215.95	.91	7	12 956.2	7	9 816.0	6.6
8	9	8	246.80	.91	8	14 807.1	8	11 218.3	8.6
9	9	9	277.65	.92	9	16 658.0	9	12 620.6	10.8
41 10	30.849	10	308.51	1850.92	10	18 509.0	0 10	14 022.9	13.4
11	9	1	339.36	.93	11	20 359.9	15	21 034.3	30.1
12	9	2	370.21	.93	12	22 210.8	20	28 045.7	53.5
13	9	3	401.06	.94	13	24 061.8	25	35 057.1	83.6
14	9	4	431.91	.95	14	25 912.7	30	42 068.5	120.4
41 15	30.849	15	462.76	1850.95	15	27 763.7	0 35	49 079.8	163.9
16	9	6	493.61	.96	16	29 614.6	40	56 091.1	214.1
17	9	7	524.46	.96	17	31 465.6	45	63 102.3	270.9
18	49	8	555.31	.97	18	33 316.5	50	70 113.5	334.5
19	50	9	586.16	.97	19	35 167.5	55	77 124.6	404.7
41 20	30.850	20	617.01	1850.98	20	37 018.5	1 00	84 135.6	481.7
21	0	1	647.86	.98	21	38 869.5	05	91 146.6	565.3
22	0	2	678.71	.99	22	40 720.4	10	98 157.4	655.6
23	0	3	709.56	0.99	23	42 571.4	15	105 168.2	752.6
24	0	4	740.41	1.00	24	44 422.4	20	112 178.9	856.3
41 25	30.850	25	771.26	1851.01	25	46 273.4	1 25	119 189.5	966.7
26	0	6	802.11	.01	26	48 124.4	30	126 200.0	1 083.8
27	0	7	832.96	.02	27	49 975.4	35	133 210.3	1 207.6
28	0	8	863.82	.02	28	51 826.5	40	140 220.6	1 338.0
29	0	9	894.67	.03	29	53 677.5	45	147 230.7	1 475.1
41 30	30.851	30	925.52	1851.03	30	55 528.5	1 50	154 240.7	1 619.0
31	1	1	956.37	.04	31	57 379.6	55	161 250.5	1 769.5
32	1	2	987.22	.04	32	59 230.6	2 00	168 260	1 927
33	1	3	1 018.07	.05	33	61 081.6	3 00	252 363	4 335
34	1	4	1 048.92	.05	34	62 932.7	4 00	336 432	7 706
41 35	30.851	35	1 079.77	1851.06	35	64 783.8	5 00	420 457	12 039
36	1	6	1 110.62	.07	36	66 634.8	6 00	504 428	17 335
37	1	7	1 141.47	.07	37	68 485.9	7 00	588 332	23 591
38	1	8	1 172.32	.08	38	70 337.0	8 00	672 159	30 807
39	1	9	1 203.17	.08	39	72 188.0	9 00	755 897	38 983
41 40	30.851	40	1 234.02	1851.09	40	74 039.1	10 00	839 537	48 118
41	2	1	1 264.87	.09	41	75 890.2	11 00	923 067	58 209
42	2	2	1 295.72	.10	42	77 741.3	12 00	1 006 475	69 256
43	2	3	1 326.57	.10	43	79 592.4	13 00	1 089 752	81 258
44	2	4	1 357.42	.11	44	81 443.5	14 00	1 172 886	94 212
41 45	30.852	45	1 388.27	1851.11	45	83 294.6	15 00	1 255 866	108 117
46	2	6	1 419.12	.12	46	85 145.7	16 00	1 338 681	122 971
47	2	7	1 449.98	.12	47	86 996.9	17 00	1 421 321	138 773
48	2	8	1 480.83	.13	48	88 848.0	18 00	1 503 775	155 520
49	2	9	1 511.68	.14	49	90 699.1	19 00	1 586 031	173 210
41 50	30.852	50	1 542.53	1851.14	50	92 550.3	20 00	1 668 079	191 841
51	2	1	1 573.38	.15	51	94 401.4	21 00	1 749 909	211 409
52	3	2	1 604.23	.15	52	96 252.5	22 00	1 831 509	231 914
53	3	3	1 635.08	.16	53	98 103.7	23 00	1 912 869	253 352
54	3	4	1 665.93	.16	54	99 954.9	24 00	1 993 978	275 719
41 55	30.853	55	1 696.78	1851.17	55	101 806.0	25 00	2 074 826	299 014
56	3	6	1 727.63	.17	56	103 657.2	26 00	2 155 402	323 233
57	3	7	1 758.48	.18	57	105 508.4	27 00	2 235 695	348 374
58	3	8	1 789.33	.18	58	107 359.6	28 00	2 315 695	374 432
59	3	9	1 820.18	.19	59	109 210.7	29 00	2 395 392	401 404
41 60	30.853	60	1 851.03	1851.20	60	111 061.9	30 00	2 474 774	429 287

Latitude 42° to 43°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
42 00	23.01	46.03	69.04	92.06	115.07	138.09	161.10	184.12	207.13	1380.9	2761.8	4142.7	5523.5	6904.4
1	.01	.02	.03	.04	.04	.05	.06	.07	.08	0.5	1.1	1.6	2.1	2.6
2	.00	6.01	9.01	2.01	5.01	8.02	1.02	4.02	7.02	0.2	60.4	40.5	20.6	900.8
3	3.00	5.99	8.99	1.99	4.98	7.98	0.98	3.97	6.97	79.8	59.6	39.4	19.2	899.0
4	2.99	.98	.97	.96	.95	.94	.93	.93	.91	9.4	8.9	8.3	7.8	7.2
42 05	22.98	45.97	68.95	91.94	114.92	137.91	160.89	183.88	206.86	1379.1	2758.2	4137.2	5516.3	6895.4
6	.98	.96	.94	.92	.89	.87	.85	.83	.81	8.7	7.5	6.2	4.9	3.6
7	.97	.95	.92	.89	.86	.84	.81	.78	.75	8.4	6.7	5.1	3.4	1.8
8	.97	.93	.90	.87	.83	.80	.76	.73	.70	8.0	6.0	4.0	2.0	90.0
9	.96	.92	.88	.84	.80	.76	.72	.68	.64	7.6	5.2	2.9	10.5	88.2
42 10	22.95	45.91	68.86	91.82	114.77	137.73	160.68	183.64	206.59	1377.3	2754.5	4131.8	5509.1	6886.4
11	.95	.90	.85	.79	.74	.69	.64	.59	.54	6.9	3.8	30.7	7.6	4.6
12	.94	.88	.83	.77	.71	.65	.60	.54	.48	6.5	3.1	29.6	6.2	2.7
13	.94	.87	.81	.75	.68	.62	.55	.49	.43	6.2	2.3	8.6	4.7	80.9
14	.93	.86	.79	.72	.65	.58	.51	.44	.37	5.8	1.6	7.5	3.3	79.1
42 15	22.92	45.85	68.77	91.70	114.62	137.55	160.47	183.40	206.32	1375.5	2750.9	4126.4	5501.9	6877.3
16	.92	.84	.75	.67	.59	.51	.43	.35	.27	5.1	50.2	5.3	500.4	5.5
17	.91	.82	.74	.65	.56	.47	.39	.30	.21	4.7	49.5	4.2	499.0	3.7
18	.91	.81	.72	.62	.53	.44	.34	.25	.16	4.4	8.7	3.1	7.5	1.9
19	.90	.80	.70	.60	.50	.40	.30	.20	.10	4.0	8.0	2.0	6.1	70.1
42 20	22.89	45.79	68.68	91.58	114.47	137.37	160.26	183.15	206.05	1373.7	2747.3	4121.0	5494.6	6868.3
21	.89	.78	.66	.55	.44	.33	.22	.11	6.00	3.3	6.6	19.9	3.2	6.4
22	.88	.76	.65	.53	.41	.29	.18	.06	5.94	2.9	5.9	8.8	1.7	4.6
23	.88	.75	.63	.50	.38	.26	.13	3.01	.89	2.6	5.1	7.7	90.2	2.8
24	.87	.74	.61	.48	.35	.22	.09	2.96	.83	2.2	4.4	6.6	88.8	61.0
42 25	22.86	45.73	68.59	91.46	114.32	137.18	160.05	182.91	205.78	1371.8	2743.7	4115.5	5487.3	6859.2
26	.86	.72	.57	.43	.29	.15	60.01	.86	.72	1.5	3.0	4.4	5.9	7.4
27	.85	.70	.56	.41	.26	.11	59.97	.81	.67	1.1	2.2	3.3	4.4	5.6
28	.85	.69	.54	.38	.23	.07	.92	.77	.61	0.7	1.5	2.2	3.0	3.7
29	.84	.68	.52	.36	.20	.04	.88	.72	.56	0.4	0.7	1.2	1.5	1.9
42 30	22.83	45.67	68.50	91.33	114.17	137.00	159.84	182.67	205.50	1370.0	2740.0	4110.1	5480.1	6850.1
31	.83	.66	.48	.31	.14	6.97	.80	.62	.45	69.7	39.3	09.0	78.6	48.3
32	.82	.64	.46	.29	.11	.93	.75	.57	.39	9.3	8.6	7.9	7.2	6.5
33	.82	.63	.45	.26	.08	.89	.71	.52	.34	8.9	7.8	6.8	5.7	4.6
34	.81	.62	.43	.24	.05	.86	.67	.48	.28	8.6	7.1	5.7	4.3	2.8
42 35	22.80	45.61	68.41	91.21	114.02	136.82	159.62	182.43	205.23	1368.2	2736.4	4104.6	5472.8	6841.0
36	.80	.59	.39	.19	3.99	.78	.58	.38	.17	7.8	5.7	3.5	71.3	39.2
37	.79	.58	.37	.17	.96	.75	.54	.33	.12	7.5	5.0	2.4	69.9	7.4
38	.78	.57	.36	.14	.93	.71	.50	.28	.07	7.1	4.2	1.3	8.4	5.5
39	.78	.56	.34	.12	.90	.67	.45	.23	5.01	6.7	3.5	100.2	7.0	3.7
42 40	22.77	45.55	68.32	91.09	113.87	136.64	159.41	182.18	204.96	1366.4	2732.8	4099.1	5465.5	6831.9
41	.77	.53	.30	.07	.84	.60	.37	.14	.90	6.0	2.0	8.0	4.0	30.1
42	.76	.52	.28	.04	.81	.56	.32	.09	.85	5.6	1.3	6.9	2.6	28.2
43	.75	.51	.26	1.02	.77	.53	.28	2.04	.79	5.3	30.6	5.8	61.1	6.4
44	.75	.50	.25	0.99	.75	.49	.24	1.99	.74	4.9	29.8	4.7	59.7	4.6
42 45	22.74	45.48	68.23	90.97	113.71	136.45	159.19	181.94	204.68	1364.5	2729.1	4093.6	5458.2	6822.7
46	.74	.47	.21	.95	.68	.42	.15	.89	.63	4.2	8.4	2.6	6.7	20.9
47	.73	.46	.19	.92	.65	.38	.11	.84	.57	3.8	7.6	1.5	5.3	19.1
48	.72	.45	.17	.90	.62	.35	.07	.79	.52	3.5	6.9	90.4	3.8	7.3
49	.72	.44	.15	.87	.59	.31	9.02	.74	.46	3.1	6.1	89.3	2.3	5.4
42 50	22.71	45.42	68.14	90.85	113.56	136.27	158.98	181.70	204.41	1362.7	2725.4	4088.2	5450.9	6813.6
51	.71	.41	.12	.82	.53	.24	.94	.65	.36	2.4	4.7	7.1	49.4	11.8
52	.70	.40	.10	.80	.50	.20	.90	.60	.30	2.0	4.0	6.0	7.9	09.9
53	.69	.39	.08	.77	.47	.16	.86	.55	.24	1.6	3.2	4.9	6.5	8.1
54	.69	.38	.06	.75	.44	.13	.81	.50	.19	1.3	2.5	3.8	5.0	6.3
42 55	22.68	45.36	68.04	90.73	113.40	136.09	158.77	181.45	204.14	1360.9	2721.8	4082.7	5443.5	6804.4
56	.68	.35	.03	.70	.38	.05	.73	.40	.08	0.5	1.1	1.6	2.1	2.6
57	.67	.34	8.01	.68	.35	6.02	.69	.35	4.02	60.2	20.3	80.5	40.6	800.8
58	.66	.33	7.99	.65	.31	5.98	.64	.30	3.96	59.8	19.6	79.4	39.1	798.9
59	.66	.31	.97	.63	.28	.94	.60	.26	.91	9.4	8.8	8.3	7.7	7.1
42 60	22.65	45.30	67.95	90.60	113.25	135.91	158.56	181.21	203.86	1359.1	2718.1	4077.2	5436.2	6795.3

Lat.	Latitude 42° to 43°—Meridional arcs.						Latitude 42°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
42 00	30.853			1851.20					
1	3	1	30.86	.20	1	1 851.2	0 1	1 380.9	0.1
2	3	2	61.71	.21	2	3 702.4	2	2 761.8	0.5
3	4	3	92.57	.21	3	5 553.6	3	4 142.7	1.2
4	4	4	123.42	.22	4	7 404.8	4	5 523.5	2.2
42 05	30.854	5	154.28	1851.22	5	9 256.0	0 5	6 904.4	3.4
6	4	6	185.14	.23	6	11 107.3	6	8 285.3	4.8
7	4	7	215.99	.23	7	12 958.5	7	9 666.2	6.6
8	4	8	246.85	.24	8	14 809.7	8	11 047.1	8.6
9	4	9	277.70	.24	9	16 661.0	9	12 428.0	10.9
42 10	30.854	10	308.56	1851.25	10	18 512.2	0 10	13 808.8	13.4
11	4	1	339.42	.26	1	20 363.5	15	20 713.2	30.2
12	4	2	370.27	.26	2	22 214.7	20	27 617.6	53.8
13	4	3	401.13	.27	3	24 066.0	25	34 522.0	84.0
14	5	4	431.98	.27	4	25 917.3	30	41 426.3	120.9
42 15	30.855	15	462.84	1851.28	15	27 768.5	0 35	48 330.6	164.6
16	5	6	493.70	.28	6	29 619.8	40	55 234.8	215.0
17	5	7	524.55	.29	7	31 471.1	45	62 139.0	272.1
18	5	8	555.41	.29	8	33 322.4	50	69 043.1	336.0
19	5	9	586.26	.30	9	35 173.7	55	75 947.2	406.5
42 20	30.855	20	617.12	1851.30	20	37 025.0	1 00	82 851.2	483.8
21	5	1	647.98	.31	1	38 876.3	05	89 755.1	567.8
22	5	2	678.83	.32	2	40 727.6	10	96 658.9	658.5
23	5	3	709.69	.32	3	42 578.9	15	103 562.6	755.9
24	5	4	740.54	.33	4	44 430.3	20	110 466.3	860.1
42 25	30.856	25	771.40	1851.33	25	46 281.6	1 25	117 369.8	971.0
26	6	6	802.26	.34	6	48 132.9	30	124 273.2	1 088.5
27	6	7	833.11	.34	7	49 984.3	35	131 176.5	1 212.8
28	6	8	863.97	.35	8	51 835.6	40	138 079.7	1 343.8
29	6	9	894.82	.35	9	53 686.9	45	144 982.7	1 481.6
42 30	30.856	30	925.68	1851.36	30	55 538.3	1 50	151 885.6	1 626.1
31	6	1	956.54	.37	1	57 389.7	55	158 788.4	1 777.2
32	6	2	987.39	.37	2	59 241.0	2 00	165 691	1 935
33	6	3	1 018.25	.38	3	61 092.4	3 00	248 508	4 354
34	6	4	1 049.10	.38	4	62 943.8	4 00	331 292	7 739
42 35	30.856	35	1 079.96	1851.39	35	64 795.2	5 00	414 030	12 092
36	7	6	1 110.82	.39	6	66 646.6	6 00	496 712	17 410
37	7	7	1 141.67	.40	7	68 498.0	7 00	579 325	23 693
38	7	8	1 172.53	.40	8	70 349.4	8 00	661 861	30 941
39	7	9	1 203.38	.41	9	72 200.8	9 00	744 305	39 152
42 40	30.857	40	1 234.24	1851.41	40	74 052.2	10 00	826 648	48 325
41	7	1	1 265.10	.42	1	75 903.6	11 00	908 879	58 459
42	7	2	1 295.95	.43	2	77 755.0	12 00	990 985	69 553
43	7	3	1 326.81	.43	3	79 606.4	13 00	1 072 956	81 605
44	7	4	1 357.66	.44	4	81 457.9	14 00	1 154 781	94 614
42 45	30.857	45	1 388.52	1851.44	45	83 309.3	15 00	1 236 449	108 577
46	7	6	1 419.38	.45	6	85 160.8	16 00	1 317 948	123 493
47	8	7	1 450.23	.45	7	87 012.2	17 00	1 399 267	139 360
48	8	8	1 481.09	.46	8	88 863.7	18 00	1 480 395	156 175
49	8	9	1 511.94	.46	9	90 715.1	19 00	1 561 321	173 937
42 50	30.858	50	1 542.80	1851.47	50	92 566.6	20 00	1 642 035	192 642
51	8	1	1 573.66	.47	1	94 418.1	21 00	1 722 524	212 289
52	8	2	1 604.51	.48	2	96 269.5	22 00	1 802 779	232 874
53	8	3	1 635.37	.49	3	98 121.0	23 00	1 882 788	254 396
54	8	4	1 666.22	.49	4	99 972.5	24 00	1 962 540	276 850
42 55	30.858	55	1 697.08	1851.50	55	101 824.0	25 00	2 042 024	300 234
56	8	6	1 727.94	.50	6	103 675.5	26 00	2 121 230	324 544
57	8	7	1 758.79	.51	7	105 527.0	27 00	2 200 146	349 778
58	9	8	1 789.65	.51	8	107 378.5	28 00	2 278 762	375 932
59	9	9	1 820.50	.52	9	109 230.0	29 00	2 357 067	403 002
42 60	30.859	60	1 851.36	1851.52	60	111 081.6	30 00	2 435 052	430 985

Latitude 43° to 44°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
43 00	22.65	45.30	67.95	90.60	113.25	135.91	158.56	181.21	203.86	1359.1	2718.1	4077.2	5436.2	6795.3
1	.64	.29	.93	.58	.22	.87	.52	.16	.81	8.7	7.4	6.1	4.7	3.4
2	.64	.28	.92	.55	.19	.83	.47	.11	.75	8.3	6.6	5.0	3.3	91.6
3	.63	.26	.90	.53	.16	.79	.43	.06	.69	7.9	5.9	3.8	1.8	89.7
4	.63	.25	.88	.50	.13	.76	.39	1.01	.64	7.6	5.1	2.7	30.3	7.9
43 05	22.62	45.24	67.86	90.48	113.10	135.72	158.34	180.96	203.58	1357.2	2714.4	4071.6	5428.9	6786.1
6	.61	.23	.84	.46	.07	.68	.30	.91	.53	6.8	3.7	70.5	7.4	4.2
7	.61	.22	.82	.43	.04	.65	.26	.86	.47	6.5	3.0	69.4	5.9	2.4
8	.60	.20	.81	.41	3.01	.61	.22	.81	.42	6.1	2.2	8.3	4.4	80.6
9	.60	.19	.79	.38	2.98	.57	.17	.77	.36	5.7	1.5	7.2	3.0	78.7
43 10	22.59	45.18	67.77	90.36	112.95	135.54	158.13	180.72	203.31	1355.4	2710.8	4066.1	5421.5	6776.9
11	.58	.17	.75	.34	.92	.50	.09	.67	.25	5.0	10.1	5.0	20.0	5.0
12	.58	.15	.73	.31	.89	.46	.04	.62	.19	4.6	09.3	3.9	18.5	3.2
13	.57	.14	.71	.29	.86	.43	8.00	.57	.14	4.3	8.6	2.8	7.1	71.3
14	.57	.13	.69	.26	.83	.39	7.96	.52	.09	3.9	7.8	1.7	5.6	69.5
43 15	22.56	45.12	67.68	90.24	112.79	135.35	157.91	180.47	203.03	1353.5	2707.1	4060.6	5414.1	6767.6
16	.55	.11	.66	.21	.76	.32	.87	.42	2.97	3.2	6.3	59.5	2.6	5.8
17	.55	.09	.64	.19	.73	.28	.83	.37	.92	2.8	5.6	8.4	11.2	4.0
18	.54	.08	.62	.16	.70	.24	.79	.32	.86	2.4	4.9	7.3	09.7	2.1
19	.53	.07	.60	.14	.67	.21	.74	.27	.81	2.1	4.1	6.2	8.2	60.3
43 20	22.53	45.06	67.58	90.11	112.64	135.17	157.70	180.22	202.75	1351.7	2703.4	4055.1	5406.7	6758.4
21	.52	.04	.57	.09	.61	.13	.65	.18	.70	1.3	2.7	4.0	5.3	6.6
22	.52	.03	.55	.06	.58	.09	.61	.13	.64	0.9	1.9	2.8	3.8	4.7
23	.51	.02	.53	.04	.55	.06	.57	.08	.59	0.6	1.2	1.7	2.3	2.9
24	.50	5.01	.51	90.01	.52	5.02	.52	80.03	.53	50.2	700.4	50.6	400.8	51.0
43 25	22.50	44.99	67.49	89.99	112.49	134.98	157.48	179.98	202.48	1349.8	2699.7	4049.5	5399.3	6749.2
26	.49	.98	.47	.96	.45	.95	.44	.93	.42	9.5	8.9	8.4	7.8	7.3
27	.49	.97	.45	.94	.42	.91	.39	.88	.37	9.1	8.2	7.3	6.4	5.5
28	.48	.96	.44	.92	.39	.87	.35	.83	.31	8.7	7.5	6.2	4.9	3.6
29	.48	.95	.42	.89	.36	.84	.31	.78	.25	8.4	6.7	5.1	3.4	41.8
43 30	22.46	44.93	67.40	89.87	112.33	134.80	157.26	179.73	202.20	1348.0	2696.0	4043.9	5391.9	6739.9
31	.46	.92	.38	.84	.30	.76	.22	.68	.14	7.6	5.2	2.8	90.4	8.1
32	.45	.91	.36	.82	.27	.72	.18	.63	.09	7.2	4.5	1.7	89.0	6.2
33	.45	.90	.34	.79	.24	.69	.13	.58	2.03	6.9	3.8	40.6	7.5	4.3
34	.44	.88	.32	.77	.21	.65	.09	.53	1.98	6.5	3.0	39.5	6.0	2.5
43 35	22.44	44.87	67.31	89.74	112.18	134.61	157.05	179.48	201.92	1346.1	2692.3	4038.4	5384.5	6730.6
36	.43	.86	.29	.72	.14	.58	7.01	.43	.86	5.8	1.5	7.3	3.0	28.8
37	.42	.85	.27	.69	.11	.54	6.96	.38	.81	5.4	0.8	6.1	1.5	6.9
38	.42	.83	.25	.67	.08	.50	.92	.34	.75	5.0	90.0	5.0	80.0	5.1
39	.41	.82	.23	.64	.05	.46	.87	.29	.70	4.6	89.3	3.9	78.6	3.2
43 40	22.40	44.81	67.21	89.62	112.02	134.43	156.83	179.24	201.64	1344.3	2688.5	4032.8	5377.1	6721.3
41	.40	.80	.19	.59	1.99	.39	.79	.19	.58	3.9	7.8	1.7	5.6	19.5
42	.39	.78	.18	.57	.96	.35	.74	.14	.53	3.5	7.0	30.6	4.1	7.6
43	.39	.77	.16	.54	.93	.32	.70	.09	.47	3.2	6.3	29.5	2.6	5.8
44	.38	.76	.14	.52	.90	.28	.66	9.04	.42	2.8	5.5	8.3	71.1	3.9
43 45	22.37	44.75	67.12	89.49	111.87	134.24	156.61	178.99	201.36	1342.4	2684.8	4027.2	5369.6	6712.0
46	.37	.73	.10	.47	.83	.20	.57	.94	.30	2.0	4.1	6.1	8.1	10.2
47	.36	.72	.08	.44	.80	.17	.53	.89	.25	1.7	3.3	5.0	6.6	08.3
48	.35	.71	.06	.42	.77	.13	.49	.84	.19	1.3	2.6	3.9	5.2	6.4
49	.35	.70	.05	.39	.74	.09	.44	.79	.14	0.9	1.8	2.7	3.7	4.6
43 50	22.34	44.68	67.03	89.37	111.71	134.05	156.40	178.74	201.08	1340.5	2681.1	4021.6	5362.2	6702.7
51	.34	.67	7.01	.35	.68	4.02	.36	.69	1.03	40.2	80.3	20.5	60.7	700.9
52	.33	.66	6.99	.32	.65	3.98	.31	.64	0.97	39.8	79.6	19.4	59.2	6699.0
53	.32	.65	.97	.29	.62	.94	.27	.59	.91	9.4	8.9	8.3	7.7	7.1
54	.32	.64	.95	.27	.59	.91	.22	.54	.86	9.1	8.1	7.2	6.2	5.3
43 55	22.31	44.62	66.93	89.25	111.56	133.87	156.18	178.49	200.80	1338.7	2677.4	4016.0	5354.7	6693.4
56	.30	.61	.92	.22	.52	.83	.14	.44	.74	8.3	6.6	4.9	3.2	91.5
57	.30	.60	.90	.20	.49	.79	.09	.39	.69	7.9	5.9	3.8	1.7	89.6
58	.29	.59	.88	.17	.46	.76	.05	.34	.63	7.6	5.1	2.7	50.2	7.8
59	.29	.57	.86	.15	.43	.72	6.00	.29	.58	7.2	4.4	1.5	48.7	5.9
43 60	22.28	44.56	66.84	89.12	111.40	133.68	155.96	178.24	200.52	1336.8	2673.6	4010.4	5347.2	6684.0

Lat.		Latitude 43° to 44°—Meridional arcs.						Latitude 43°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
43	00	30.859			1851.52						
	1	9	1	30.86	.53	1	1 851.5	0	1	1 359.1	0.1
	2	9	2	61.72	.53	2	3 703.1		2	2 718.1	0.5
	3	9	3	92.58	.54	3	5 554.6		3	4 077.2	1.2
	4	9	4	123.45	.55	4	7 406.1		4	5 436.2	2.2
43	05	30.859	5	154.31	1851.55	5	9 257.7	0	5	6 795.3	3.4
	6	9	6	185.17	.56	6	11 109.2		6	8 154.3	4.9
	7	9	7	216.03	.56	7	12 960.8		7	9 513.4	6.6
	8	59	8	246.89	.57	8	14 812.4		8	10 872.4	8.6
	9	60	9	277.75	.57	9	16 663.9		9	12 231.5	10.9
43	10	30.860	10	308.61	1851.58	10	18 515.5	0	10	13 590.5	13.5
	11	0	1	339.48	.58	1	20 367.1		15	20 385.8	30.3
	12	0	2	370.34	.59	2	22 218.7		20	27 181.0	53.9
	13	0	3	401.20	.59	3	24 070.3		25	33 976.2	84.3
	14	0	4	432.06	.60	4	25 921.9		30	40 771.4	121.3
43	15	30.860	15	462.92	1851.61	15	27 773.5	0	35	47 566.5	165.1
	16	0	6	493.78	.61	6	29 625.1		40	54 361.6	215.7
	17	0	7	524.64	.62	7	31 476.7		45	61 156.7	273.0
	18	0	8	555.51	.62	8	33 328.3		50	67 951.6	337.0
	19	0	9	586.37	.63	9	35 179.9		55	74 746.5	407.8
43	20	30.861	20	617.23	1851.63	20	37 031.6	1	00	81 541.3	485.3
	21	1	1	648.09	.64	1	38 883.2		05	88 336.1	569.6
	22	1	2	678.95	.64	2	40 734.8		10	95 130.7	660.5
	23	1	3	709.81	.65	3	42 586.5		15	101 925.3	758.3
	24	1	4	740.68	.65	4	44 438.1		20	108 719.8	862.8
43	25	30.861	25	771.54	1851.66	25	46 289.8	1	25	115 514.2	974.0
	26	1	6	802.40	.67	6	48 141.4		30	122 308.4	1 091.9
	27	1	7	833.26	.67	7	49 993.1		35	129 102.5	1 216.6
	28	1	8	864.12	.68	8	51 844.8		40	135 896.5	1 348.0
	29	1	9	894.98	.68	9	53 696.5		45	142 690.4	1 486.2
43	30	30.861	30	925.84	1851.69	30	55 548.2	1	50	149 484.1	1 631.1
	31	2	1	956.71	.69	1	57 399.9		55	156 277.7	1 782.8
	32	2	2	987.57	.70	2	59 251.6	2	00	163 071	1 941
	33	2	3	1 018.43	.70	3	61 103.3	3	00	244 578	4 367
	34	2	4	1 049.29	.71	4	62 955.0	4	00	326 050	7 763
43	35	30.862	35	1 080.15	1851.72	35	64 806.7	5	00	407 476	12 129
	36	2	6	1 111.01	.72	6	66 658.4	6	00	488 844	17 464
	37	2	7	1 141.87	.73	7	68 510.1	7	00	570 148	23 766
	38	2	8	1 172.74	.73	8	70 361.9	8	00	651 361	31 036
	39	2	9	1 203.60	.74	9	72 213.6	9	00	732 486	39 272
43	40	30.862	40	1 234.46	1851.74	40	74 065.3	10	00	813 508	48 474
	41	2	1	1 265.32	.75	1	75 917.1	11	00	894 415	58 639
	42	3	2	1 296.18	.75	2	77 768.8	12	00	975 195	69 766
	43	3	3	1 327.04	.76	3	79 620.5	13	00	1 055 837	81 854
	44	3	4	1 357.90	.76	4	81 472.3	14	00	1 136 329	94 901
43	45	30.863	45	1 388.77	1851.77	45	83 324.1	15	00	1 216 661	108 905
	46	3	6	1 419.63	.78	6	85 175.8	16	00	1 296 820	123 864
	47	3	7	1 450.49	.78	7	87 027.6	17	00	1 376 795	139 777
	48	3	8	1 481.35	.79	8	88 879.4	18	00	1 456 575	156 640
	49	3	9	1 512.21	.79	9	90 731.2	19	00	1 536 148	174 451
43	50	30.863	50	1 543.07	1851.80	50	92 583.0	20	00	1 615 505	193 209
	51	3	1	1 573.93	.80	1	94 434.8	21	00	1 694 632	212 909
	52	3	2	1 604.80	.81	2	96 286.6	22	00	1 773 519	233 551
	53	4	3	1 635.66	.81	3	98 138.4	23	00	1 852 155	255 129
	54	4	4	1 666.52	.82	4	99 990.3	24	00	1 930 528	277 642
43	55	30.864	55	1 697.38	1851.82	55	101 842.1	25	00	2 008 628	301 087
	56	4	6	1 728.24	.83	6	103 693.9	26	00	2 086 443	325 459
	57	4	7	1 759.10	.84	7	105 545.7	27	00	2 163 963	350 756
	58	4	8	1 789.96	.84	8	107 397.6	28	00	2 241 176	376 974
	59	4	9	1 820.83	.85	9	109 249.4	29	00	2 318 071	404 109
43	60	30.864	60	1 851.69	1851.85	60	111 101.3	30	00	2 394 639	432 157

Latitude 44° to 45°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
44 00	22.28	44.56	66.84	89.12	111.40	133.68	155.96	178.24	200.52	1336.8	2673.6	4010.4	5347.2	6684.0
1	.27	.55	.82	.10	.37	.64	.92	.19	.46	6.4	2.9	09.3	5.7	2.2
2	.27	.54	.80	.07	.34	.61	.87	.14	.41	6.1	2.1	8.2	4.2	80.3
3	.26	.52	.78	.05	.31	.57	.83	.09	.35	5.7	1.4	7.0	2.7	78.4
4	.26	.51	.76	.02	.28	.53	.78	8.04	.30	5.3	70.6	5.9	41.2	6.5
44 05	22.25	44.50	66.75	89.00	111.24	133.49	155.74	177.99	200.24	1334.9	2669.9	4004.8	5339.7	6674.7
6	.24	.49	.73	8.97	.21	.46	.70	.94	.18	4.6	9.1	3.7	8.2	2.8
7	.24	.47	.71	.95	.18	.42	.65	.89	.13	4.2	8.4	2.6	6.7	70.9
8	.23	.46	.69	.92	.15	.38	.61	.84	.07	3.8	7.6	1.4	5.2	69.0
9	.22	.45	.67	.90	.13	.34	.57	.79	200.02	3.4	6.9	4000.3	3.7	7.2
44 10	22.22	44.44	66.65	88.87	111.09	133.31	155.52	177.74	199.96	1333.1	2666.1	3999.2	5332.2	6665.3
11	.21	.42	.63	.85	.06	.27	.48	.69	.90	2.7	5.4	8.1	30.7	3.4
12	.21	.41	.61	.82	.03	.23	.43	.64	.85	2.3	4.6	6.9	29.2	61.5
13	.20	.40	.60	.80	1.00	.19	.39	.59	.79	1.9	3.9	5.8	7.7	59.7
14	.20	.39	.58	.77	0.97	.16	.35	.54	.74	1.6	3.1	4.7	6.2	7.8
44 15	22.19	44.37	66.56	88.75	110.93	133.12	155.30	177.49	199.68	1331.2	2662.4	3993.5	5324.7	6655.9
16	.18	.36	.54	.72	.90	.08	.26	.44	.62	0.8	1.6	2.4	3.2	4.0
17	.17	.35	.52	.70	.87	.04	.22	.39	.57	0.4	0.9	1.3	1.7	2.1
18	.17	.34	.50	.67	.84	3.01	.18	.34	.51	30.1	60.1	90.2	20.2	50.3
19	.16	.32	.48	.65	.81	2.97	.13	.29	.45	29.7	59.4	89.0	18.7	48.4
44 20	22.16	44.31	66.47	88.62	110.78	132.93	155.09	177.24	199.40	1329.3	2658.6	3987.9	5317.2	6646.5
21	.15	.30	.45	.59	.74	.89	.04	.19	.34	8.9	7.8	6.8	5.7	4.6
22	.14	.28	.43	.57	.71	.85	5.00	.14	.28	8.5	7.1	5.6	4.2	2.7
23	.14	.27	.41	.54	.68	.82	4.96	.09	.23	8.2	6.3	4.5	2.7	40.8
24	.13	.26	.39	.52	.65	.78	.91	7.04	.17	7.8	5.6	3.4	11.2	39.0
44 25	22.12	44.25	66.37	88.49	110.62	132.74	154.87	176.99	199.11	1327.4	2654.8	3982.2	5309.7	6637.1
26	.12	.23	.35	.47	.59	.70	.82	.94	.06	7.0	4.1	1.1	8.2	5.2
27	.11	.22	.33	.44	.55	.67	.77	.89	9.00	6.7	3.3	80.0	6.6	3.3
28	.10	.21	.31	.42	.52	.63	.74	.84	8.94	6.3	2.6	78.9	5.1	31.4
29	.10	.20	.30	.39	.49	.59	.69	.79	.89	5.9	1.8	7.7	3.6	29.5
44 30	22.09	44.18	66.28	88.37	110.46	132.55	154.65	176.74	198.83	1325.5	2651.1	3976.6	5302.1	6627.7
31	.08	.17	.26	.34	.42	.52	.61	.69	.77	5.2	50.3	5.5	300.6	5.8
32	.08	.16	.24	.32	.40	.48	.56	.64	.72	4.8	49.6	4.3	299.1	3.9
33	.07	.15	.22	.29	.37	.44	.52	.59	.66	4.4	8.8	3.2	7.6	2.0
34	.07	.13	.20	.27	.34	.40	.47	.54	.60	4.0	8.1	2.0	6.1	20.1
44 35	22.06	44.12	66.18	88.24	110.30	132.36	154.43	176.49	198.55	1323.6	2647.3	3970.9	5294.6	6618.2
36	.05	.11	.16	.22	.27	.33	.38	.43	.49	3.3	6.5	69.8	3.0	6.3
37	.05	.10	.14	.19	.24	.29	.34	.38	.43	2.9	5.8	8.6	1.5	4.4
38	.04	.08	.13	.17	.21	.25	.29	.33	.37	2.5	5.0	7.5	90.0	2.5
39	.04	.07	.11	.14	.18	.21	.25	.28	.32	2.1	4.3	6.4	88.5	10.6
44 40	22.03	44.06	66.09	88.12	110.15	132.17	154.20	176.23	198.26	1321.7	2643.5	3965.2	5287.0	6608.7
41	.02	.04	.07	.09	.12	.14	.16	.18	.20	1.4	2.7	4.1	5.5	6.8
42	.02	.03	.05	.07	.09	.10	.11	.13	.15	1.0	2.0	3.0	4.0	4.9
43	.01	.02	.05	.04	.05	.06	.07	.08	.09	0.6	1.2	1.8	2.4	3.1
44	.00	.01	6.01	8.02	10.02	2.02	4.02	6.03	8.03	20.2	40.5	60.7	80.9	601.2
44 45	22.00	44.00	65.99	87.99	109.99	131.99	153.98	175.98	197.98	1319.9	2639.7	3959.6	5279.4	6599.3
46	1.99	3.98	.97	.96	.96	.95	.94	.93	.92	9.5	8.9	8.4	7.9	7.4
47	.99	.97	.96	.94	.93	.91	.89	.88	.86	9.1	8.2	7.3	6.4	5.5
48	.98	.96	.94	.91	.89	.87	.85	.83	.80	8.7	7.4	6.1	4.9	3.6
49	.97	.95	.92	.89	.86	.83	.80	.78	.75	8.3	6.7	5.0	3.3	91.7
44 50	21.97	43.93	65.90	87.86	109.83	131.80	153.76	175.73	197.69	1318.0	2635.9	3953.9	5271.8	6589.8
51	.96	.92	.88	.84	.80	.76	.72	.68	.63	7.6	5.1	2.7	70.3	7.9
52	.95	.91	.86	.81	.77	.72	.67	.63	.58	7.2	4.4	1.6	68.8	6.0
53	.95	.89	.84	.79	.73	.68	.63	.58	.52	6.8	3.6	50.4	7.3	4.1
54	.94	.88	.82	.76	.70	.64	.58	.52	.46	6.4	2.9	49.3	5.7	2.2
44 55	21.93	43.87	65.80	87.74	109.67	131.61	153.54	175.47	197.41	1316.1	2632.1	3948.2	5264.2	6580.3
56	.93	.86	.78	.71	.64	.57	.50	.42	.35	5.7	1.3	7.0	2.7	78.4
57	.92	.84	.77	.69	.61	.53	.45	.37	.29	5.3	30.6	5.9	61.2	6.5
58	.92	.83	.75	.66	.57	.49	.41	.32	.23	4.9	29.8	4.7	59.6	4.6
59	.91	.82	.73	.64	.54	.45	.36	.27	.18	4.5	9.1	3.6	8.1	2.7
44 60	21.90	43.81	65.71	87.61	109.51	131.42	153.32	175.22	197.12	1314.2	2628.3	3942.5	5256.6	6570.8

Lat.	Latitude 44° to 45°—Meridional arcs.						Latitude 44°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
44 00	30.864			1851.85					
1	4	1	30.87	.86	1	1 851.9	0 1	1 336.8	0.1
2	4	2	61.73	.86	2	3 703.7	2	2 673.6	0.5
3	4	3	92.60	.87	3	5 555.6	3	4 010.4	1.2
4	5	4	123.47	.87	4	7 407.4	4	5 347.2	2.2
44 05	30.865	5	154.33	1851.88	5	9 259.3	0 5	6 684.0	3.4
6	5	6	185.20	.89	6	11 111.2	6	8 020.8	4.9
7	5	7	216.07	.89	7	12 963.1	7	9 357.7	6.6
8	5	8	246.94	.90	8	14 815.0	8	10 694.5	8.6
9	5	9	277.80	.90	9	16 666.9	9	12 031.3	10.9
44 10	30.865	10	308.67	1851.91	10	18 518.8	0 10	13 368.1	13.5
11	5	1	339.54	.91	1	20 370.7	15	20 052.1	30.4
12	5	2	370.40	.92	2	22 222.6	20	26 736.1	54.0
13	5	3	401.27	.92	3	24 074.5	25	33 420.1	84.4
14	5	4	432.14	.93	4	25 926.5	30	40 104.0	121.5
44 15	30.866	15	463.00	1851.93	15	27 778.4	0 35	46 787.9	165.4
16	6	6	493.87	.94	6	29 630.3	40	53 471.8	216.1
17	6	7	524.74	.95	7	31 482.3	45	60 155.6	273.5
18	6	8	555.61	.95	8	33 334.2	50	66 839.3	337.7
19	6	9	586.47	.96	9	35 186.2	55	73 523.0	408.6
44 20	30.866	20	617.34	1851.96	20	37 038.1	1 00	80 206.5	486.2
21	6	1	648.21	.97	1	38 890.1	05	86 890.0	570.6
22	6	2	679.07	.97	2	40 742.0	10	93 573.5	661.8
23	6	3	709.94	.98	3	42 594.0	15	100 256.8	759.7
24	6	4	740.81	.98	4	44 446.0	20	106 940.0	864.4
44 25	30.866	25	771.67	1851.99	25	46 298.0	1 25	113 623.1	975.8
26	7	6	802.54	1.99	6	48 150.0	30	120 306.1	1 094.0
27	7	7	833.41	2.00	7	50 002.0	35	126 989.0	1 218.9
28	7	8	864.27	.01	8	51 854.0	40	133 671.8	1 350.6
29	7	9	895.14	.01	9	53 706.0	45	140 354.4	1 489.0
44 30	30.867	30	926.01	1852.02	30	55 558.0	1 50	147 036.8	1 634.2
31	7	1	956.88	.02	1	57 410.0	55	153 719.1	1 786.1
32	7	2	987.74	.03	2	59 262.0	2 00	160 401	1 945
33	7	3	1 018.61	.03	3	61 114.1	3 00	240 572	4 375
34	7	4	1 049.48	.04	4	62 966.1	4 00	320 708	7 778
44 35	30.867	35	1 080.34	1852.04	35	64 818.1	5 00	400 797	12 152
36	7	6	1 111.21	.05	6	66 670.2	6 00	480 827	17 496
37	8	7	1 142.08	.06	7	68 522.2	7 00	560 786	23 811
38	8	8	1 172.94	.06	8	70 374.3	8 00	640 662	31 094
39	8	9	1 203.81	.07	9	72 226.4	9 00	720 445	39 345
44 40	30.868	40	1 234.68	1852.07	40	74 078.4	10 00	800 122	48 563
41	8	1	1 265.54	.08	1	75 930.5	11 00	879 681	58 746
42	8	2	1 296.41	.08	2	77 782.6	12 00	959 110	69 893
43	8	3	1 327.28	.09	3	79 634.7	13 00	1 038 399	82 002
44	8	4	1 358.15	.09	4	81 486.8	14 00	1 117 535	95 072
44 45	30.868	45	1 389.01	1852.10	45	83 338.9	15 00	1 196 507	109 100
46	8	6	1 419.88	.10	6	85 191.0	16 00	1 275 303	124 084
47	9	7	1 450.75	.11	7	87 043.1	17 00	1 353 911	140 023
48	9	8	1 481.61	.12	8	88 895.2	18 00	1 432 320	156 913
49	9	9	1 512.48	.12	9	90 747.3	19 00	1 510 519	174 753
44 50	30.869	50	1 543.35	1852.13	50	92 599.5	20 00	1 588 496	193 540
51	9	1	1 574.21	.13	1	94 451.6	21 00	1 666 240	213 270
52	9	2	1 605.08	.14	2	96 303.7	22 00	1 743 738	233 942
53	9	3	1 635.95	.14	3	98 155.9	23 00	1 820 980	255 552
54	9	4	1 666.82	.15	4	100 008.0	24 00	1 897 955	278 096
44 55	30.869	55	1 697.68	1852.15	55	101 860.2	25 00	1 974 650	301 572
56	9	6	1 728.55	.16	6	103 712.3	26 00	2 051 055	325 977
57	69	7	1 759.42	.16	7	105 564.5	27 00	2 127 159	351 306
58	70	8	1 790.28	.17	8	107 416.7	28 00	2 202 950	377 555
59	0	9	1 821.15	.18	9	109 268.8	29 00	2 278 417	404 722
44 60	30.870	60	1 852.02	1852.18	60	111 121.0	30 00	2 353 550	432 801

Latitude 45° to 46°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
45 00	21.90	43.81	65.71	87.61	109.51	131.42	153.32	175.22	197.12	1314.2	2628.3	3942.5	5256.6	6570.8
1	.90	.79	.69	.58	.48	.38	.28	.17	.06	3.8	7.5	1.3	5.1	68.8
2	.89	.78	.67	.56	.45	.34	.23	.12	7.01	3.4	6.8	40.2	3.6	6.9
3	.88	.77	.65	.53	.42	.30	.19	.07	6.95	3.0	6.0	39.0	2.0	5.0
4	.88	.75	.63	.51	.39	.26	.14	5.02	.89	2.6	5.3	7.9	50.5	3.1
45 05	21.87	43.74	65.61	87.48	109.35	131.22	153.10	174.97	196.83	1312.2	2624.5	3936.7	5249.0	6561.2
6	.86	.73	.59	.46	.32	.19	.05	.91	.78	1.9	3.7	5.6	7.4	59.3
7	.86	.72	.57	.43	.29	.15	3.01	.86	.72	1.5	3.0	4.4	5.9	7.4
8	.85	.70	.56	.41	.26	.11	2.96	.81	.66	1.1	2.2	3.3	4.4	5.5
9	.85	.69	.54	.38	.23	.07	.92	.76	.61	0.7	1.5	2.2	2.9	3.6
45 10	21.84	43.68	65.52	87.36	109.20	131.03	152.87	174.71	196.55	1310.3	2620.7	3931.0	5241.3	6551.7
11	.83	.67	.50	.33	.17	1.00	.83	.66	.49	10.0	19.9	29.9	39.8	49.8
12	.83	.65	.48	.30	.13	0.96	.78	.61	.44	09.6	09.1	8.7	8.3	7.9
13	.82	.64	.46	.28	.10	.92	.74	.56	.38	9.2	8.4	7.6	6.8	5.9
14	.81	.63	.44	.25	.07	.88	.69	.51	.32	8.8	7.6	6.4	5.2	4.0
45 15	21.81	43.61	65.42	87.23	109.04	130.84	152.65	174.46	196.26	1308.4	2616.8	3925.3	5233.7	6542.1
16	.80	.60	.40	.20	9.01	.80	.61	.41	.21	8.0	6.1	4.1	2.2	40.2
17	.79	.59	.38	.18	8.98	.77	.56	.35	.15	7.7	5.3	3.0	30.6	38.3
18	.79	.58	.36	.15	.94	.73	.52	.30	.09	7.3	4.5	1.8	29.1	6.4
19	.78	.56	.35	.13	.91	.69	.47	.25	6.04	6.9	3.8	20.7	7.6	4.5
45 20	21.78	43.55	65.33	87.10	108.88	130.65	152.43	174.20	195.98	1306.5	2613.0	3919.5	5226.0	6532.5
21	.77	.54	.31	.07	.85	.61	.39	.15	.92	6.1	2.2	8.4	4.5	30.6
22	.76	.52	.29	.05	.82	.57	.34	.10	.86	5.7	1.5	7.2	3.0	28.7
23	.76	.51	.27	.02	.78	.54	.30	.05	.81	5.4	0.7	6.1	21.4	6.8
24	.75	.50	.25	7.00	.75	.50	.25	4.00	.75	5.0	10.0	4.9	19.9	4.9
45 25	21.74	43.49	65.23	86.97	108.72	130.46	152.21	173.95	195.69	1304.6	2609.2	3913.8	5218.4	6523.0
26	.74	.47	.21	.95	.69	.42	.16	.89	.63	4.2	8.4	2.6	6.8	21.0
27	.73	.46	.19	.92	.66	.38	.12	.84	.57	3.8	7.6	1.5	5.3	19.1
28	.72	.45	.17	.90	.62	.34	.07	.79	.52	3.4	6.9	10.3	3.8	7.2
29	.72	.44	.15	.87	.59	.31	2.03	.74	.46	3.1	6.1	09.2	2.2	5.3
45 30	21.71	43.42	65.13	86.84	108.56	130.27	151.98	173.69	195.40	1302.7	2605.3	3908.0	5210.7	6513.4
31	.70	.41	.11	.82	.53	.23	.94	.64	.34	2.3	4.5	6.9	09.1	11.4
32	.70	.40	.09	.79	.50	.19	.89	.59	.28	1.9	3.8	5.7	7.6	09.5
33	.69	.38	.08	.77	.46	.15	.85	.54	.23	1.5	3.0	4.6	6.1	7.6
34	.69	.37	.06	.74	.43	.11	.80	.48	.17	1.1	2.3	3.4	4.5	5.7
45 35	21.68	43.36	65.04	86.72	108.40	130.07	151.76	173.43	195.11	1300.7	2601.5	3902.2	5203.0	6503.7
36	.67	.35	.02	.69	.37	.04	.71	.38	5.05	0.4	600.7	901.1	201.4	501.8
37	.67	.33	5.00	.66	.34	30.00	.67	.33	4.99	300.0	599.9	899.9	199.9	499.9
38	.66	.32	4.98	.64	.30	29.96	.62	.28	.94	299.6	9.2	8.8	8.4	8.0
39	.65	.31	.96	.61	.27	.92	.58	.23	.88	9.2	8.4	7.6	6.8	6.0
45 40	21.65	43.29	64.94	86.59	108.24	129.88	151.53	173.18	194.82	1298.8	2597.6	3896.5	5195.3	6494.1
41	.64	.28	.92	.56	.20	.84	.48	.12	.76	8.4	6.8	5.3	3.7	2.2
42	.63	.27	.90	.54	.17	.81	.44	.07	.71	8.1	6.1	4.2	2.2	90.3
43	.63	.26	.88	.51	.14	.77	.40	3.02	.65	7.7	5.3	3.0	90.7	88.3
44	.62	.24	.86	.49	.11	.73	.35	2.97	.59	7.3	4.6	1.8	89.1	6.4
45 45	21.61	43.23	64.85	86.46	108.07	129.69	151.31	172.92	194.54	1296.9	2593.8	3890.7	5187.6	6484.5
46	.61	.22	.83	.43	.04	.65	.26	.87	.48	6.5	3.0	89.5	6.0	2.5
47	.60	.20	.81	.41	8.01	.61	.22	.82	.42	6.1	2.2	8.4	4.5	80.6
48	.60	.19	.79	.38	7.98	.57	.17	.76	.36	5.7	1.5	7.2	2.9	78.7
49	.59	.18	.77	.36	.94	.53	.13	.71	.30	5.3	90.7	6.0	81.4	6.7
45 50	21.58	43.17	64.75	86.33	107.91	129.50	151.08	172.66	194.25	1295.0	2589.9	3884.9	5179.9	6474.8
51	.58	.15	.73	.30	.88	.46	1.04	.61	.19	4.6	9.1	3.7	8.3	2.9
52	.57	.14	.71	.28	.85	.42	0.99	.56	.13	4.2	8.4	2.6	6.8	70.9
53	.56	.13	.69	.25	.81	.38	.95	.51	.07	3.8	7.6	1.4	5.2	69.0
54	.56	.11	.67	.23	.78	.34	.90	.46	4.01	3.4	6.9	80.2	3.7	7.1
45 55	21.55	43.10	64.65	86.20	107.75	129.30	150.86	172.40	193.96	1293.0	2586.1	3879.1	5172.1	6465.1
56	.54	.09	.63	.18	.72	.26	.81	.35	.90	2.6	5.3	7.9	70.6	3.2
57	.54	.08	.61	.15	.69	.23	.77	.30	.84	2.3	4.5	6.8	69.0	61.3
58	.53	.06	.59	.13	.65	.19	.72	.25	.78	1.9	3.8	5.6	7.5	59.3
59	.52	.05	.57	.10	.62	.15	.68	.20	.72	1.5	3.0	4.4	5.9	7.4
45 60	21.52	43.04	64.55	86.07	107.59	129.11	150.63	172.15	193.66	1291.1	2582.2	3873.3	5164.4	6455.5

Lat.		Latitude 45° to 46°—Meridional arcs.						Latitude 45°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
45	00	30.870			1852.18						
	1	0	1	30.87	.19	1	1 852.2	0	1	1 314.1	0.1
	2	0	2	61.74	.19	2	3 704.4		2	2 628.3	0.5
	3	0	3	92.62	.20	3	5 556.6		3	3 942.5	1.2
	4	0	4	123.49	.20	4	7 408.8		4	5 256.6	2.2
45	05	30.870	5	154.36	1852.21	5	9 261.0	0	5	6 570.8	3.4
	6	0	6	185.23	.21	6	11 113.2		6	7 884.9	4.9
	7	0	7	216.11	.22	7	12 965.4		7	9 199.1	6.6
	8	0	8	246.98	.23	8	14 817.6		8	10 513.2	8.6
	9	1	9	277.85	.23	9	16 669.9		9	11 827.4	10.9
45	10	30.871	10	308.72	1852.24	10	18 522.1	0	10	13 141.5	13.5
	11	1	1	339.60	.24	1	20 374.3		15	19 712.3	30.4
	12	1	2	370.47	.25	2	22 226.6		20	26 283.0	54.1
	13	1	3	401.34	.25	3	24 078.8		25	32 853.7	84.5
	14	1	4	432.21	.26	4	25 931.1		30	39 424.3	121.6
45	15	30.871	15	463.09	1852.26	15	27 783.3	0	35	45 994.9	165.6
	16	1	6	493.96	.27	6	29 635.6		40	52 565.5	216.2
	17	1	7	524.83	.27	7	31 487.9		45	59 136.0	273.7
	18	1	8	555.70	.28	8	33 340.1		50	65 706.5	337.9
	19	1	9	586.58	.29	9	35 192.4		55	72 276.8	408.8
45	20	30.872	20	617.45	1852.29	20	37 044.7	1	00	78 847.1	486.5
	21	2	1	648.32	.30	1	38 897.0		05	85 417.4	571.0
	22	2	2	679.19	.30	2	40 749.3		10	91 987.5	662.2
	23	2	3	710.07	.31	3	42 601.6		15	98 557.5	760.2
	24	2	4	740.94	.31	4	44 453.9		20	105 127.4	865.0
45	25	30.872	25	771.81	1852.32	25	46 306.2	1	25	111 697.3	976.5
	26	2	6	802.68	.32	6	48 158.6		30	118 267.0	1 094.7
	27	2	7	833.56	.33	7	50 010.9		35	124 836.6	1 219.7
	28	2	8	864.43	.34	8	51 863.2		40	131 406.0	1 351.5
	29	2	9	895.30	.34	9	53 715.6		45	137 975.3	1 490.0
45	30	30.872	30	926.17	1852.35	30	55 567.9	1	50	144 544.4	1 635.3
	31	3	1	957.05	.35	1	57 420.3		55	151 113.5	1 787.3
	32	3	2	987.92	.36	2	59 272.6	2	00	157 682	1 946
	33	3	3	1 018.79	.36	3	61 125.0	3	00	236 493	4 378
	34	3	4	1 049.66	.37	4	62 977.3	4	00	315 269	7 783
45	35	30.873	35	1 080.54	1852.37	35	64 829.7	5	00	393 996	12 160
	36	3	6	1 111.41	.38	6	66 682.1	6	00	472 663	17 508
	37	3	7	1 142.28	.38	7	68 534.5	7	00	551 258	23 826
	38	3	8	1 173.15	.39	8	70 386.9	8	00	629 769	31 114
	39	3	9	1 204.02	.40	9	72 239.3	9	00	708 184	39 370
45	40	30.873	40	1 234.90	1852.40	40	74 091.7	10	00	786 492	48 594
	41	3	1	1 265.77	.41	1	75 944.1	11	00	864 679	58 782
	42	4	2	1 296.64	.41	2	77 796.5	12	00	942 735	69 936
	43	4	3	1 327.51	.42	3	79 648.9	13	00	1 020 647	82 051
	44	4	4	1 358.39	.42	4	81 501.3	14	00	1 098 404	95 127
45	45	30.874	45	1 389.26	1852.43	45	83 353.7	15	00	1 175 994	109 162
	46	4	6	1 420.13	.43	6	85 206.1	16	00	1 253 404	124 153
	47	4	7	1 451.00	.44	7	87 058.6	17	00	1 330 624	140 099
	48	4	8	1 481.88	.44	8	88 911.0	18	00	1 407 640	156 996
	49	4	9	1 512.75	.45	9	90 763.5	19	00	1 484 443	174 842
45	50	30.874	50	1 543.62	1852.46	50	92 615.9	20	00	1 561 019	193 635
	51	4	1	1 574.49	.46	1	94 468.4	21	00	1 637 358	213 371
	52	4	2	1 605.37	.47	2	96 320.9	22	00	1 713 447	234 048
	53	5	3	1 636.24	.47	3	98 173.3	23	00	1 789 276	255 663
	54	5	4	1 667.11	.48	4	100 025.8	24	00	1 864 831	278 211
45	55	30.875	55	1 697.98	1852.48	55	101 878.3	25	00	1 940 103	301 690
	56	5	6	1 728.86	.49	6	103 730.8	26	00	2 015 079	326 097
	57	5	7	1 759.73	.49	7	105 583.3	27	00	2 089 749	351 427
	58	5	8	1 790.60	.50	8	107 435.8	28	00	2 164 100	377 676
	59	5	9	1 821.47	.51	9	109 288.3	29	00	2 238 121	404 841
45	60	30.875	60	1 852.35	1852.51	60	111 140.8	30	00	2 311 802	432 918

Latitude 46° to 47°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
46 00	21.52	43.04	64.55	86.07	107.59	129.11	150.63	172.15	193.66	1291.1	2582.2	3873.3	5164.4	6455.5
1	.51	.02	.53	.05	.56	.07	.58	.09	.60	0.7	1.4	2.1	2.8	3.5
2	.51	.01	.52	6.02	.53	9.03	.54	2.04	.55	90.3	80.6	70.9	61.3	51.6
3	.50	3.00	.50	5.99	.49	8.99	.49	1.99	.49	89.9	79.9	69.8	59.7	49.6
4	.49	2.98	.48	.97	.46	.95	.45	.94	.43	9.5	9.1	8.6	8.2	7.7
46 05	21.48	42.97	64.46	85.94	107.43	128.92	150.40	171.89	193.37	1289.2	2578.3	3867.5	5156.6	6445.8
6	.48	.96	.44	.92	.40	.88	.35	.84	.31	8.8	7.5	6.3	5.1	3.8
7	.47	.95	.42	.89	.37	.84	.31	.78	.25	8.4	6.7	5.1	3.5	41.9
8	.47	.93	.40	.87	.33	.80	.26	.73	.20	8.0	6.0	4.0	1.9	39.9
9	.46	.92	.38	.84	.30	.76	.22	.68	.14	7.6	5.2	2.8	50.4	8.0
46 10	21.45	42.91	64.36	85.81	107.27	128.72	150.17	171.63	193.08	1287.2	2574.4	3861.6	5148.8	6436.1
11	.45	.89	.34	.79	.24	.68	.13	.58	3.02	6.8	3.6	60.5	7.3	4.1
12	.44	.88	.32	.76	.20	.64	.08	.52	2.96	6.4	2.8	59.3	5.7	2.2
13	.43	.87	.30	.74	.17	.60	50.04	.47	.91	6.0	2.1	8.1	4.2	30.2
14	.43	.86	.28	.71	.14	.57	49.99	.42	.85	5.7	1.3	7.0	2.6	28.3
46 15	21.42	42.84	64.26	85.68	107.10	128.53	149.95	171.37	192.79	1285.3	2570.5	3855.8	5141.1	6426.3
16	.41	.83	.24	.66	.07	.49	.90	.32	.73	4.9	69.7	4.6	39.5	4.4
17	.41	.82	.22	.63	.04	.45	.86	.26	.67	4.5	8.9	3.5	7.9	2.4
18	.40	.80	.21	.61	7.01	.41	.81	.21	.62	4.1	8.2	2.3	6.4	20.5
19	.39	.79	.19	.58	6.97	.37	.77	.16	.56	3.7	7.4	1.1	4.8	18.5
46 20	21.39	42.78	64.17	85.55	106.94	128.33	149.72	171.11	192.50	1283.3	2566.6	3850.0	5133.3	6416.6
21	.38	.76	.15	.53	.91	.29	.68	.06	.44	2.9	5.8	48.8	1.7	4.6
22	.38	.75	.13	.50	.88	.25	.63	1.00	.38	2.5	5.0	7.6	30.1	2.7
23	.37	.74	.11	.48	.84	.21	.59	0.95	.32	2.1	4.3	6.4	28.6	10.7
24	.36	.73	.09	.45	.81	.18	.54	.90	.26	1.8	3.5	5.3	7.0	08.8
46 25	21.36	42.71	64.07	85.42	106.78	128.14	149.50	170.85	192.21	1281.4	2562.7	3844.1	5125.5	6406.8
26	.35	.70	.05	.40	.75	.10	.45	.80	.15	1.0	1.9	2.9	3.9	4.9
27	.34	.69	.03	.37	.72	.06	.41	.74	.09	0.6	1.1	1.8	2.3	2.9
28	.33	.67	4.01	.35	.68	8.02	.36	.69	2.03	80.2	60.4	40.6	20.8	401.0
29	.33	.66	3.99	.32	.65	7.98	.32	.64	1.97	79.8	59.6	39.4	19.2	399.0
46 30	21.32	42.65	63.97	85.29	106.62	127.94	149.27	170.59	191.91	1279.4	2558.8	3838.2	5117.7	6397.1
31	.32	.63	.95	.27	.59	.90	.22	.54	.85	9.0	8.0	7.1	6.1	5.1
32	.31	.62	.93	.24	.55	.86	.18	.48	.79	8.6	7.2	5.9	4.5	3.2
33	.30	.61	.91	.22	.52	.82	.13	.43	.73	8.2	6.5	4.7	3.0	91.2
34	.30	.59	.89	.19	.48	.78	.08	.38	.67	7.8	5.7	3.5	11.4	89.2
46 35	21.29	42.58	63.87	85.16	106.45	127.75	149.04	170.33	191.62	1277.5	2554.9	3832.4	5109.8	6387.3
36	.28	.57	.85	.14	.42	.71	8.99	.28	.56	7.1	4.1	1.2	8.3	5.3
37	.28	.56	.83	.11	.39	.67	.95	.22	.50	6.7	3.3	30.0	6.7	3.4
38	.27	.54	.81	.09	.36	.63	.90	.17	.44	6.3	2.6	28.8	5.1	81.4
39	.26	.53	.79	.06	.32	.59	.86	.12	.38	5.9	1.8	7.7	3.6	79.5
46 40	21.26	42.52	63.77	85.03	106.29	127.55	148.81	170.07	191.32	1275.5	2551.0	3826.5	5102.0	6377.5
41	.25	.50	.75	5.01	.26	.51	.76	70.01	.26	5.1	50.2	5.3	100.4	5.5
42	.25	.49	.74	4.98	.22	.47	.72	69.96	.21	4.7	49.4	4.1	098.9	3.6
43	.24	.48	.72	.96	.19	.43	.67	.91	.15	4.3	8.7	3.0	7.3	71.6
44	.23	.46	.70	.93	.16	.39	.63	.86	.09	3.9	7.9	1.8	5.7	69.6
46 45	21.23	42.45	63.68	84.90	106.12	127.35	148.58	169.80	191.03	1273.5	2547.1	3820.6	5094.1	6367.7
46	.22	.44	.66	.88	.09	.31	.53	.75	0.97	3.1	6.3	19.4	2.6	5.7
47	.21	.43	.64	.85	.06	.28	.49	.70	.91	2.8	5.5	8.3	91.0	3.8
48	.21	.41	.62	.83	6.03	.24	.44	.65	.86	2.4	4.8	7.1	89.4	61.8
49	.20	.40	.60	.80	5.99	.20	.40	.60	.80	2.0	4.0	5.9	7.9	59.8
46 50	21.19	42.39	63.58	84.77	105.96	127.16	148.35	169.54	190.74	1271.6	2543.2	3814.7	5086.3	6357.9
51	.19	.37	.56	.75	.93	.12	.30	.49	.68	1.2	2.4	3.5	4.7	5.9
52	.18	.36	.54	.72	.90	.08	.26	.44	.62	0.8	1.6	2.4	3.1	3.9
53	.17	.35	.52	.69	.86	.04	.21	.39	.56	0.4	0.8	1.2	1.6	2.0
54	.17	.33	.50	.67	.83	7.00	.17	.33	.50	70.0	40.0	10.0	80.0	50.0
46 55	21.16	42.32	63.48	84.64	105.80	126.96	148.12	169.28	190.44	1269.6	2539.2	3808.8	5078.4	6348.0
56	.15	.31	.46	.61	.77	.92	.07	.23	.38	9.2	8.4	7.6	6.9	6.1
57	.15	.29	.44	.59	.74	.88	8.03	.18	.33	8.8	7.6	6.5	5.3	4.1
58	.14	.28	.42	.56	.70	.84	7.98	.12	.27	8.4	6.9	5.3	3.7	2.1
59	.13	.27	.40	.54	.67	.80	.94	.07	.21	8.0	6.1	4.1	2.1	40.2
46 60	21.13	42.25	63.38	84.51	105.64	126.76	147.89	169.02	190.15	1267.6	2535.3	3802.9	5070.6	6338.2

Lat.		Latitude 46° to 47°—Meridional arcs.						Latitude 46°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
46	00	30.875			1852.51						
	1	5	1	30.88	.52	1	1 852.5	0	1	1 291.1	0.1
	2	5	2	61.76	.52	2	3 705.0		2	2 582.2	0.5
	3	5	3	92.63	.53	3	5 557.6		3	3 873.3	1.2
	4	6	4	123.51	.53	4	7 410.1		4	5 164.4	2.2
46	05	30.876	5	154.39	1852.54	5	9 262.6	0	5	6 455.5	3.4
	6	6	6	185.27	.54	6	11 115.2		6	7 746.6	4.9
	7	6	7	216.15	.55	7	12 967.7		7	9 037.6	6.6
	8	6	8	247.02	.55	8	14 820.3		8	10 328.7	8.6
	9	6	9	277.90	.56	9	16 672.8		9	11 619.8	10.9
46	10	30.876	10	308.78	1852.57	10	18 525.4	0	10	12 910.9	13.5
	11	6	1	339.66	.57	1	20 377.9		15	19 366.4	30.4
	12	6	2	370.54	.58	2	22 230.5		20	25 821.8	54.0
	13	6	3	401.41	.58	3	24 083.1		25	32 277.2	84.4
	14	6	4	432.29	.59	4	25 935.7		30	38 732.6	121.6
46	15	30.877	15	463.17	1852.59	15	27 788.3	0	35	45 187.9	165.5
	16	7	6	494.05	.60	6	29 640.9		40	51 643.1	216.1
	17	7	7	524.92	.60	7	31 493.5		45	58 098.4	273.5
	18	7	8	555.80	.61	8	33 346.1		50	64 553.5	337.7
	19	7	9	586.68	.61	9	35 198.7		55	71 008.6	408.6
46	20	30.877	20	617.56	1852.62	20	37 051.3	1	00	77 463.6	486.3
	21	7	1	648.44	.63	1	38 903.9		05	83 918.5	570.7
	22	7	2	679.31	.63	2	40 756.6		10	90 373.3	661.9
	23	7	3	710.19	.64	3	42 609.2		15	96 828.0	759.8
	24	7	4	741.07	.64	4	44 461.8		20	103 282.7	864.5
46	25	30.877	25	771.95	1852.65	25	46 314.5	1	25	109 737.2	975.9
	26	8	6	802.83	.65	6	48 167.1		30	116 191.6	1 094.1
	27	8	7	833.70	.66	7	50 019.8		35	122 645.8	1 219.0
	28	8	8	864.58	.66	8	51 872.4		40	129 099.9	1 350.7
	29	8	9	895.46	.67	9	53 725.1		45	135 553.9	1 489.2
46	30	30.878	30	926.34	1852.68	30	55 577.8	1	50	142 007.8	1 634.4
	31	8	1	957.22	.68	1	57 430.5		55	148 461.4	1 786.3
	32	8	2	988.09	.69	2	59 283.1	2	00	154 915	1 945
	33	8	3	1 018.97	.69	3	61 135.8	3	00	232 342	4 376
	34	8	4	1 049.85	.70	4	62 988.5	4	00	309 732	7 779
46	35	30.878	35	1 080.73	1852.70	35	64 841.2	5	00	387 074	12 153
	36	8	6	1 111.61	.71	6	66 693.9	6	00	464 354	17 498
	37	9	7	1 142.48	.71	7	68 546.6	7	00	541 562	23 813
	38	9	8	1 173.36	.72	8	70 399.4	8	00	618 684	31 096
	39	9	9	1 204.24	.72	9	72 252.1	9	00	695 708	39 347
46	40	30.879	40	1 235.12	1852.73	40	74 104.8	10	00	772 623	48 565
	41	9	1	1 265.99	.74	1	75 957.5	11	00	849 416	58 747
	42	9	2	1 296.87	.74	2	77 810.3	12	00	926 075	69 893
	43	9	3	1 327.75	.75	3	79 663.0	13	00	1 002 588	82 000
	44	9	4	1 358.63	.75	4	81 515.8	14	00	1 078 943	95 067
46	45	30.879	45	1 389.51	1852.76	45	83 368.5	15	00	1 155 128	109 091
	46	9	6	1 420.38	.76	6	85 221.3	16	00	1 231 131	124 071
	47	79	7	1 451.26	.77	7	87 074.1	17	00	1 306 940	140 003
	48	80	8	1 482.14	.77	8	88 926.8	18	00	1 382 543	156 887
	49	0	9	1 513.02	.78	9	90 779.6	19	00	1 457 928	174 718
46	50	30.880	50	1 543.90	1852.78	50	92 632.4	20	00	1 533 083	193 494
	51	0	1	1 574.77	.79	1	94 485.2	21	00	1 607 997	213 212
	52	0	2	1 605.65	.80	2	96 338.0	22	00	1 682 657	233 869
	53	0	3	1 636.53	.80	3	98 190.8	23	00	1 757 052	255 462
	54	0	4	1 667.41	.81	4	100 043.6	24	00	1 831 170	277 987
46	55	30.880	55	1 698.29	1852.81	55	101 896.4	25	00	1 904 999	301 441
	56	0	6	1 729.16	.82	6	103 749.2	26	00	1 978 528	325 820
	57	0	7	1 760.04	.82	7	105 602.0	27	00	2 051 745	351 120
	58	0	8	1 790.92	.83	8	107 454.8	28	00	2 124 639	377 337
	59	1	9	1 821.80	.83	9	109 307.7	29	00	2 197 197	404 468
46	60	30.881	60	1 852.68	1852.84	60	111 160.5	30	00	2 269 410	432 507

Latitude 47° to 48°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
47 00	21.13	42.25	63.38	84.51	105.64	126.76	147.89	169.02	190.15	1267.6	2535.3	3802.9	5070.6	6338.2
1	.12	.24	.36	.48	.61	.72	.84	8.97	.09	7.2	4.5	1.7	69.0	6.2
2	.11	.23	.34	.46	.57	.68	.80	.91	90.03	6.8	3.7	800.5	7.4	4.2
3	.11	.22	.32	.43	.54	.65	.75	.86	89.97	6.5	2.9	799.4	5.8	2.3
4	.10	.20	.30	.40	.51	.61	.71	.81	.91	6.1	2.1	8.2	4.2	30.3
47 05	21.09	42.19	63.28	84.38	105.47	126.57	147.66	168.76	189.85	1265.7	2531.3	3797.0	5062.7	6328.3
6	.09	.18	.26	.35	.44	.53	.61	.70	.79	5.3	30.5	5.8	61.1	6.4
7	.08	.16	.24	.32	.41	.49	.57	.65	.73	4.9	29.7	4.6	59.5	4.4
8	.07	.15	.22	.30	.38	.45	.52	.60	.67	4.5	9.0	3.4	7.9	2.4
9	.07	.14	.20	.27	.34	.41	.48	.54	.61	4.1	8.2	2.3	6.3	20.4
47 10	21.06	42.12	63.18	84.25	105.31	126.37	147.43	168.49	189.55	1263.7	2527.4	3791.1	5054.8	6318.5
11	.05	.11	.16	.22	.28	.33	.38	.44	.49	3.3	6.6	89.9	3.2	6.5
12	.05	.10	.14	.19	.24	.29	.34	.39	.43	2.9	5.8	8.7	1.6	4.5
13	.04	.08	.12	.17	.21	.25	.29	.33	.37	2.5	5.0	7.5	50.0	2.5
14	.04	.07	.10	.14	.18	.21	.25	.28	.31	2.1	4.2	6.3	48.4	10.5
47 15	21.03	42.06	63.09	84.11	105.15	126.17	147.20	168.23	189.26	1261.7	2523.4	3785.1	5046.8	6308.6
16	.02	.04	.07	.09	.11	.13	.15	.18	.20	1.3	2.6	3.9	5.3	6.6
17	.02	.03	.05	.06	.08	.09	.11	.12	.14	0.9	1.8	2.8	3.7	4.6
18	.01	.02	.03	.04	.05	.05	.06	.07	.08	0.5	1.1	1.6	2.1	2.6
19	.00	2.00	3.01	4.01	5.01	6.01	7.02	8.02	9.02	60.1	20.3	80.4	40.5	300.6
47 20	21.00	41.99	62.99	83.98	104.98	125.97	146.97	167.96	188.96	1259.7	2519.5	3779.2	5038.9	6298.7
21	0.99	.98	.97	.96	.95	.93	.92	.91	.90	9.3	8.7	8.0	7.3	6.7
22	.98	.96	.95	.93	.91	.89	.88	.86	.84	8.9	7.9	6.8	5.8	4.7
23	.98	.95	.93	.90	.88	.85	.83	.81	.78	8.5	7.1	5.6	4.2	2.7
24	.97	.94	.91	.88	.85	.81	.79	.75	.72	8.1	6.3	4.4	2.6	90.7
47 25	20.96	41.92	62.89	83.85	104.81	125.77	146.74	167.70	188.66	1257.7	2515.5	3773.2	5031.0	6288.7
26	.96	.91	.87	.82	.78	.74	.69	.65	.60	7.4	4.7	2.1	29.4	6.8
27	.95	.90	.85	.80	.75	.70	.65	.59	.54	7.0	3.9	70.9	7.8	4.8
28	.94	.89	.83	.77	.72	.66	.60	.54	.48	6.6	3.1	69.7	6.2	2.8
29	.94	.87	.81	.74	.68	.62	.56	.49	.42	6.2	2.3	8.5	4.6	80.8
47 30	20.93	41.86	62.79	83.72	104.65	125.58	146.51	167.44	188.36	1255.8	2511.5	3767.3	5023.1	6278.8
31	.92	.85	.77	.69	.62	.54	.46	.38	.30	5.4	10.7	6.1	21.5	6.8
32	.92	.83	.75	.66	.58	.50	.42	.33	.24	5.0	09.9	4.9	19.9	4.8
33	.91	.82	.73	.64	.55	.46	.37	.28	.18	4.6	9.1	3.7	8.3	2.9
34	.90	.81	.71	.61	.52	.42	.32	.22	.12	4.2	8.3	2.5	6.7	70.9
47 35	20.90	41.79	62.69	83.58	104.48	125.38	146.28	167.17	188.07	1253.8	2507.5	3761.3	5015.1	6268.9
36	.89	.78	.67	.56	.45	.34	.23	.12	8.01	3.4	6.7	60.1	3.5	6.9
37	.88	.77	.65	.53	.42	.30	.18	.06	7.95	3.0	5.9	58.9	1.9	4.9
38	.88	.75	.63	.51	.39	.26	.13	7.01	.89	2.6	5.2	7.7	10.3	2.9
39	.87	.74	.61	.48	.35	.22	.09	6.96	.83	2.2	4.4	6.5	08.7	60.9
47 40	20.86	41.73	62.59	83.45	104.32	125.18	146.04	166.90	187.77	1251.8	2503.6	3755.4	5007.1	6258.9
41	.86	.71	.57	.43	.29	.14	5.99	.85	.71	1.4	2.8	4.2	5.5	6.9
42	.85	.70	.55	.40	.25	.10	.95	.80	.65	1.0	2.0	3.0	4.0	4.9
43	.84	.69	.53	.37	.22	.06	.90	.75	.59	0.6	1.2	1.8	2.4	2.9
44	.84	.67	.51	.35	.18	5.02	.86	.69	.53	50.2	500.4	50.6	5000.8	50.9
47 45	20.83	41.66	62.49	83.32	104.15	124.98	145.81	166.64	187.47	1249.8	2499.6	3749.4	4999.2	6248.9
46	.82	.65	.47	.29	.12	.94	.76	.59	.41	9.4	8.8	8.2	7.6	7.0
47	.82	.63	.45	.27	.08	.90	.72	.53	.35	9.0	8.0	7.0	6.0	5.0
48	.81	.62	.43	.24	.05	.86	.67	.48	.29	8.6	7.2	5.8	4.4	3.0
49	.80	.61	.41	.21	4.01	.82	.63	.43	.23	8.2	6.4	4.6	2.8	41.0
47 50	20.80	41.59	62.39	83.19	103.98	124.78	145.58	166.37	187.17	1247.8	2495.6	3743.4	4991.2	6239.0
51	.79	.58	.37	.16	.95	.74	.53	.32	.11	7.4	4.8	2.2	89.6	7.0
52	.78	.57	.35	.13	.91	.70	.49	.27	7.05	7.0	4.0	41.0	8.0	5.0
53	.78	.55	.33	.11	.88	.66	.44	.21	6.99	6.6	3.2	39.8	6.4	3.0
54	.77	.54	.31	.08	.85	.62	.39	.16	.93	6.2	2.4	8.6	4.8	31.0
47 55	20.76	41.53	62.29	83.05	103.81	124.58	145.35	166.11	186.87	1245.8	2491.6	3737.4	4983.2	6229.0
56	.76	.51	.27	.03	.78	.54	.30	.05	.81	5.4	0.8	6.2	1.6	7.0
57	.75	.50	.25	3.00	.75	.50	.25	6.00	.75	5.0	90.0	5.0	80.0	5.0
58	.74	.49	.23	2.97	.72	.46	.20	5.95	.69	4.6	89.2	3.8	78.4	3.0
59	.74	.47	.21	.95	.68	.42	.16	.89	.63	4.2	8.4	2.6	6.8	21.0
47 60	20.73	41.46	62.19	82.92	103.65	124.38	145.11	165.84	186.57	1243.8	2487.6	3731.4	4975.2	6219.0

Lat.	Latitude 47° to 48°—Meridional arcs.						Latitude 47°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
47 00	30.881			1852.84					
1	1	1	30.88	.85	1	1 852.8	0 1	1 267.6	0.1
2	1	2	61.77	.85	2	3 705.7	2	2 535.3	0.5
3	1	3	92.65	.86	3	5 558.5	3	3 802.9	1.2
4	1	4	123.53	.86	4	7 411.4	4	5 070.5	2.2
47 05	30.881	5	154.42	1852.87	5	9 264.3	0 5	6 338.2	3.4
6	1	6	185.30	.87	6	11 117.1	6	7 605.8	4.8
7	1	7	216.18	.88	7	12 970.0	7	8 873.5	6.6
8	1	8	247.07	.88	8	14 822.9	8	10 141.1	8.6
9	1	9	277.95	.89	9	16 675.8	9	11 408.7	10.9
47 10	30.882	10	308.83	1852.89	10	18 528.7	0 10	12 676.4	13.5
11	2	1	339.72	.90	1	20 381.6	15	19 014.6	30.3
12	2	2	370.60	.91	2	22 234.5	20	25 352.7	53.9
13	2	3	401.48	.91	3	24 087.4	25	31 690.8	84.3
14	2	4	432.37	.92	4	25 940.3	30	38 028.9	121.4
47 15	30.882	15	463.25	1852.92	15	27 793.2	0 35	44 366.9	165.2
16	2	6	494.13	.93	6	29 646.1	40	50 704.9	215.7
17	2	7	525.02	.93	7	31 499.1	45	57 042.9	273.0
18	2	8	555.90	.94	8	33 352.0	50	63 380.7	337.1
19	2	9	586.78	.94	9	35 204.9	55	69 718.5	407.9
47 20	30.882	20	617.67	1852.95	20	37 057.9	1 00	76 056.3	485.4
21	3	1	648.55	.95	1	38 910.8	05	82 393.9	569.7
22	3	2	679.43	.96	2	40 763.8	10	88 731.4	660.7
23	3	3	710.32	.97	3	42 616.8	15	95 068.9	758.4
24	3	4	741.20	.97	4	44 469.7	20	101 406.2	862.9
47 25	30.883	25	772.08	1852.98	25	46 322.7	1 25	107 743.4	974.2
26	3	6	802.97	.98	6	48 175.7	30	114 080.5	1 092.2
27	3	7	833.85	.99	7	50 028.7	35	120 417.5	1 216.9
28	3	8	864.74	2.99	8	51 881.7	40	126 754.3	1 348.3
29	3	9	895.62	3.00	9	53 734.7	45	133 091.0	1 486.5
47 30	30.883	30	926.50	1853.00	30	55 587.7	1 50	139 427.6	1 631.5
31	3	1	957.39	.01	1	57 440.7	55	145 764.0	1 783.2
32	4	2	988.27	.01	2	59 293.7	2 00	152 100	1 942
33	4	3	1 019.15	.02	3	61 146.7	3 00	228 119	4 368
34	4	4	1 050.04	.03	4	62 999.7	4 00	304 101	7 765
47 35	30.884	35	1 080.92	1853.03	35	64 852.7	5 00	380 034	12 131
36	4	6	1 111.80	.04	6	66 705.8	6 00	455 904	17 467
37	4	7	1 142.69	.04	7	68 558.8	7 00	531 700	23 770
38	4	8	1 173.57	.05	8	70 411.9	8 00	607 410	31 040
39	4	9	1 204.45	.05	9	72 264.9	9 00	683 020	39 276
47 40	30.884	40	1 235.34	1853.06	40	74 118.0	10 00	758 520	48 477
41	4	1	1 266.22	.06	1	75 971.0	11 00	833 895	58 640
42	4	2	1 297.10	.07	2	77 824.1	12 00	909 135	69 765
43	5	3	1 327.99	.08	3	79 677.2	13 00	984 227	81 849
44	5	4	1 358.87	.08	4	81 530.2	14 00	1 059 158	94 890
47 45	30.885	45	1 389.75	1853.09	45	83 383.3	15 00	1 133 917	108 887
46	5	6	1 420.64	.09	6	85 236.4	16 00	1 208 491	123 837
47	5	7	1 451.52	.10	7	87 089.5	17 00	1 282 868	139 738
48	5	8	1 482.40	.10	8	88 942.6	18 00	1 357 036	156 587
49	5	9	1 513.29	.11	9	90 795.7	19 00	1 430 984	174 381
47 50	30.885	50	1 544.17	1853.11	50	92 648.8	20 00	1 504 697	193 118
51	5	1	1 575.05	.12	1	94 501.9	21 00	1 578 166	212 793
52	5	2	1 605.94	.12	2	96 355.1	22 00	1 651 377	233 405
53	5	3	1 636.82	.13	3	98 208.2	23 00	1 724 320	254 950
54	6	4	1 667.70	.14	4	100 061.3	24 00	1 796 982	277 425
47 55	30.886	55	1 698.59	1853.14	55	101 914.5	25 00	1 869 351	300 824
56	6	6	1 729.47	.15	6	103 767.6	26 00	1 941 415	325 146
57	6	7	1 760.35	.15	7	105 620.8	27 00	2 013 163	350 386
58	6	8	1 791.24	.16	8	107 473.9	28 00	2 084 583	376 539
59	6	9	1 822.12	.16	9	109 327.1	29 00	2 155 663	403 602
47 60	30.886	60	1 853.00	1853.17	60	111 180.2	30 00	2 226 392	431 569

Latitude 48° to 49°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
48 00	20.73	41.46	62.19	82.92	103.65	124.38	145.11	165.84	186.57	1243.8	2487.6	3731.4	4975.2	6219.0
1	.72	.45	.17	.89	.62	.34	.06	.79	.51	3.4	6.8	30.2	3.6	7.0
2	.72	.43	.15	.87	.58	.30	5.02	.73	.45	3.0	6.0	29.0	2.0	5.0
3	.71	.42	.13	.84	.55	.26	4.97	.68	.39	2.6	5.2	7.8	70.4	3.0
4	.70	.41	.11	.81	.52	.22	.92	.63	.33	2.2	4.4	6.6	68.8	10.9
48 05	20.70	41.39	62.09	82.79	103.48	124.18	144.88	165.57	186.27	1241.8	2483.6	3725.4	4967.2	6208.9
6	.69	.38	.07	.76	.45	.14	.83	.52	.21	1.4	2.8	4.2	5.5	6.9
7	.68	.37	.05	.73	.42	.10	.78	.46	.15	1.0	2.0	3.0	3.9	4.9
8	.68	.35	.03	.71	.39	.06	.73	.41	.09	0.6	1.2	1.8	2.3	2.9
9	.67	.34	2.01	.68	.35	4.02	.69	.36	6.03	40.2	80.4	20.6	60.7	200.9
48 10	20.66	41.33	61.99	82.65	103.32	123.98	144.64	165.30	185.97	1239.8	2479.6	3719.4	4959.1	6198.9
11	.66	.31	.97	.63	.29	.94	.59	.25	.91	9.4	8.8	8.1	7.5	6.9
12	.65	.30	.95	.60	.25	.90	.55	.20	.85	9.0	8.0	6.9	5.9	4.9
13	.64	.29	.93	.57	.22	.86	.50	.14	.79	8.6	7.1	5.7	4.3	2.9
14	.64	.27	.91	.54	.18	.82	.45	.09	.73	8.2	6.3	4.5	2.7	90.9
48 15	20.63	41.26	61.89	82.52	103.15	123.78	144.41	165.04	185.66	1237.8	2475.5	3713.3	4951.1	6188.9
16	.62	.25	.87	.49	.12	.74	.36	4.98	.60	7.4	4.7	2.1	49.5	6.8
17	.62	.23	.85	.46	.08	.70	.31	.93	.54	7.0	3.9	10.9	7.9	4.8
18	.61	.22	.83	.44	.05	.66	.26	.88	.48	6.6	3.1	09.7	6.3	2.8
19	.60	.21	.81	.41	3.01	.62	.22	.82	.42	6.2	2.3	8.5	4.7	80.8
48 20	20.60	41.19	61.79	82.38	102.98	123.58	144.17	164.77	185.36	1235.8	2471.5	3707.3	4943.0	6178.8
21	.59	.18	.77	.36	.95	.54	.12	.71	.30	5.4	70.7	6.1	41.4	6.8
22	.58	.17	.75	.33	.91	.50	.08	.66	.24	5.0	69.9	4.9	39.8	4.8
23	.58	.15	.73	.30	.88	.46	4.03	.61	.18	4.6	9.1	3.7	8.2	2.8
24	.57	.14	.71	.28	.85	.42	3.98	.55	.12	4.2	8.3	2.5	6.6	70.8
48 25	20.56	41.12	61.69	82.25	102.81	123.37	143.93	164.50	185.06	1233.7	2467.5	3701.2	4935.0	6168.7
26	.56	.11	.67	.22	.78	.33	.89	.45	5.00	3.3	6.7	700.0	3.4	6.7
27	.55	.10	.65	.20	.74	.29	.84	.39	4.94	2.9	5.9	698.8	1.8	4.7
28	.54	.08	.63	.17	.71	.25	.79	.34	.88	2.5	5.1	7.6	30.1	2.7
29	.54	.07	.61	.14	.67	.21	.75	.28	.82	2.1	4.3	6.4	28.5	60.7
48 30	20.53	41.06	61.59	82.12	102.64	123.17	143.70	164.23	184.76	1231.7	2463.5	3695.2	4926.9	6158.7
31	.52	.04	.57	.09	.61	.13	.65	.18	.70	1.3	2.7	4.0	5.3	6.6
32	.52	.03	.55	.06	.57	.09	.61	.12	.64	0.9	1.9	2.8	3.7	4.6
33	.51	.02	.53	.03	.54	.05	.56	.07	.58	0.5	1.0	1.5	2.1	2.6
34	.50	1.00	.51	2.01	.51	3.01	.51	4.01	.52	30.1	60.2	90.3	20.4	50.6
48 35	20.50	40.99	61.48	81.98	102.47	122.97	143.47	163.96	184.45	1229.7	2459.4	3689.1	4918.8	6148.5
36	.49	.98	.46	.95	.44	.93	.42	.91	.39	9.3	8.6	7.9	7.2	6.5
37	.48	.96	.44	.93	.41	.89	.37	.85	.33	8.9	7.8	6.7	5.6	4.5
38	.47	.95	.42	.90	.38	.85	.32	.80	.27	8.5	7.0	5.5	4.0	2.5
39	.47	.94	.40	.87	.34	.81	.28	.75	.21	8.1	6.2	4.3	2.4	40.5
48 40	20.46	40.92	61.38	81.85	102.31	122.77	143.23	163.69	184.15	1227.7	2455.4	3683.1	4910.7	6138.4
41	.45	.91	.36	.82	.28	.73	.18	.64	.09	7.3	4.6	1.8	09.1	6.4
42	.45	.90	.34	.79	.24	.69	.14	.58	4.03	6.9	3.8	80.6	7.5	4.4
43	.44	.88	.32	.76	.21	.65	.09	.53	3.97	6.5	2.9	79.4	5.9	2.4
44	.43	.87	.30	.74	.17	.61	.04	.48	.91	6.1	2.1	8.2	4.3	30.3
48 45	20.43	40.86	61.28	81.71	102.14	122.57	143.00	163.42	183.85	1225.7	2451.3	3677.0	4902.6	6128.3
46	.42	.84	.26	.68	.11	.53	2.95	.37	.79	5.3	50.5	5.8	901.0	6.3
47	.41	.83	.24	.66	.07	.48	.90	.31	.73	4.8	49.7	4.5	899.4	4.2
48	.41	.81	.22	.63	.04	.44	.85	.26	.67	4.4	8.9	3.3	7.8	2.2
49	.40	.80	.20	.60	2.00	.40	.81	.21	.61	4.0	8.1	2.1	6.2	20.2
48 50	20.39	40.79	61.18	81.58	101.97	122.36	142.76	163.15	183.55	1223.6	2447.3	3670.9	4894.5	6118.2
51	.39	.77	.16	.55	.94	.32	.71	.10	.49	3.2	6.5	69.7	2.9	6.1
52	.38	.76	.14	.52	.90	.28	.66	3.04	.43	2.8	5.7	8.5	91.3	4.1
53	.37	.75	.12	.49	.87	.24	.62	2.99	.36	2.4	4.8	7.2	89.7	2.1
54	.37	.73	.10	.47	.83	.20	.57	.93	.30	2.0	4.0	6.0	8.0	10.0
48 55	20.36	40.72	61.08	81.44	101.80	122.16	142.52	162.88	183.24	1221.6	2443.2	3664.8	4886.4	6108.0
56	.35	.71	.06	.41	.77	.12	.47	.83	.18	1.2	2.4	3.6	4.8	6.0
57	.35	.69	.04	.39	.73	.08	.42	.77	.12	0.8	1.6	2.4	3.1	3.9
58	.34	.68	.02	.36	.70	.04	.38	.72	3.05	0.4	40.7	61.1	81.5	101.9
59	.33	.67	1.00	.33	.66	2.00	.33	.66	2.99	20.0	39.9	59.9	79.9	099.9
48 60	20.33	40.65	60.98	81.30	101.63	121.96	142.28	162.61	182.93	1219.6	2439.1	3658.7	4878.3	6097.8

Lat.		Latitude 48° to 49°—Meridional arcs.						Latitude 48°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
48	00	30.886			1853.17						
	1	6	1	30.89	.17	1	1 853.2	0	1	1 243.8	0.1
	2	6	2	61.78	.18	2	3 706.3		2	2 487.6	0.5
	3	6	3	92.67	.18	3	5 559.5		3	3 731.4	1.2
	4	6	4	123.56	.19	4	7 412.7		4	4 975.2	2.1
48	05	30.887	5	154.44	1853.20	5	9 265.9	0	5	6 219.0	3.3
	6	7	6	185.33	.20	6	11 119.1		6	7 462.8	4.8
	7	7	7	216.22	.21	7	12 972.3		7	8 706.6	6.6
	8	7	8	247.11	.21	8	14 825.5		8	9 950.4	8.6
	9	7	9	278.00	.22	9	16 678.7		9	11 194.2	10.9
48	10	30.887	10	308.89	1853.22	10	18 531.9	0	10	12 437.9	13.4
	11	7	1	339.78	.23	1	20 385.2		15	18 656.9	30.2
	12	7	2	370.67	.23	2	22 238.4		20	24 875.8	53.8
	13	7	3	401.56	.24	3	24 091.6		25	31 094.7	84.0
	14	7	4	432.44	.24	4	25 944.9		30	37 313.6	121.0
48	15	30.887	15	463.33	1853.25	15	27 798.1	0	35	43 532.4	164.7
	16	8	6	494.22	.26	6	29 651.4		40	49 751.2	215.1
	17	8	7	525.11	.26	7	31 504.6		45	55 969.9	272.2
	18	8	8	556.00	.27	8	33 357.9		50	62 188.5	336.1
	19	8	9	586.89	.27	9	35 211.2		55	68 407.1	406.7
48	20	30.888	20	617.78	1853.28	20	37 064.4	1	00	74 625.6	484.0
	21	8	1	648.67	.28	1	38 917.7		05	80 844.0	568.0
	22	8	2	679.56	.29	2	40 771.0		10	87 062.3	658.7
	23	8	3	710.44	.29	3	42 624.3		15	93 280.5	756.2
	24	8	4	741.33	.30	4	44 477.6		20	99 498.6	860.4
48	25	30.888	25	772.22	1853.30	25	46 330.9	1	25	105 716.6	971.3
	26	8	6	803.11	.31	6	48 184.2		30	111 934.5	1 088.9
	27	9	7	834.00	.32	7	50 037.5		35	118 152.2	1 213.2
	28	9	8	864.89	.32	8	51 890.8		40	124 369.8	1 344.3
	29	9	9	895.78	.33	9	53 744.2		45	130 587.3	1 482.1
48	30	30.889	30	926.67	1853.33	30	55 597.5	1	50	136 804.6	1 626.6
	31	9	1	957.55	.34	1	57 450.8		55	143 021.7	1 777.8
	32	9	2	988.44	.34	2	59 304.2	2	00	149 239	1 936
	33	9	3	1 019.33	.35	3	61 157.5	3	00	223 827	4 355
	34	9	4	1 050.22	.35	4	63 010.9	4	00	298 377	7 742
48	35	30.889	35	1 081.11	1853.36	35	64 864.2	5	00	372 877	12 095
	36	9	6	1 112.00	.36	6	66 717.6	6	00	447 314	17 414
	37	89	7	1 142.89	.37	7	68 570.9	7	00	521 677	23 698
	38	90	8	1 173.78	.38	8	70 424.3	8	00	595 951	30 946
	39	0	9	1 204.67	.38	9	72 277.7	9	00	670 125	39 157
48	40	30.890	40	1 235.55	1853.39	40	74 131.1	10	00	744 186	48 329
	41	0	1	1 266.44	.39	1	75 984.5	11	00	818 123	58 461
	42	0	2	1 297.33	.40	2	77 837.9	12	00	891 921	69 552
	43	0	3	1 328.22	.40	3	79 691.3	13	00	965 570	81 598
	44	0	4	1 359.11	.41	4	81 544.7	14	00	1 039 056	94 598
48	45	30.890	45	1 390.00	1853.41	45	83 398.1	15	00	1 112 367	108 551
	46	0	6	1 420.89	.42	6	85 251.5	16	00	1 185 491	123 453
	47	0	7	1 451.78	.42	7	87 104.9	17	00	1 258 416	139 302
	48	0	8	1 482.67	.43	8	88 958.3	18	00	1 331 129	156 096
	49	1	9	1 513.55	.44	9	90 811.8	19	00	1 403 618	173 832
48	50	30.891	50	1 544.44	1853.44	50	92 665.2	20	00	1 475 871	192 506
	51	1	1	1 575.33	.45	1	94 518.7	21	00	1 547 876	212 116
	52	1	2	1 606.22	.45	2	96 372.1	22	00	1 619 620	232 658
	53	1	3	1 637.11	.46	3	98 225.6	23	00	1 691 091	254 128
	54	1	4	1 668.00	.46	4	100 079.0	24	00	1 762 279	276 524
48	55	30.891	55	1 698.89	1853.47	55	101 932.5	25	00	1 833 170	299 842
	56	1	6	1 729.78	.47	6	103 786.0	26	00	1 903 752	324 077
	57	1	7	1 760.67	.48	7	105 639.4	27	00	1 974 015	349 225
	58	1	8	1 791.55	.48	8	107 492.9	28	00	2 043 945	375 283
	59	1	9	1 822.44	.49	9	109 346.4	29	00	2 113 531	402 245
48	60	30.892	60	1 853.33	1853.50	60	111 199.9	30	00	2 182 762	430 107

Latitude 49° to 50°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
49 00	20.33	40.65	60.98	81.30	101.63	121.96	142.28	162.61	182.93	1219.6	2439.1	3658.7	4878.3	6097.8
1	.32	.64	.96	.28	.60	.92	.23	.55	.87	9.2	8.3	7.5	6.6	5.8
2	.31	.63	.94	.25	.56	.88	.19	.50	.81	8.8	7.5	6.3	5.0	3.8
3	.31	.61	.92	.22	.53	.83	.14	.45	.75	8.3	6.7	5.0	3.4	91.7
4	.30	.60	.90	.20	.49	.79	.09	.39	.69	7.9	5.9	3.8	1.8	89.7
49 05	20.29	40.58	60.88	81.17	101.46	121.75	142.04	162.34	182.63	1217.5	2435.1	3652.6	4870.1	6087.7
6	.29	.57	.86	.14	.43	.71	2.00	.28	.57	7.1	4.3	1.4	68.5	5.6
7	.28	.56	.84	.12	.39	.67	1.95	.23	.51	6.7	3.5	50.2	6.9	3.6
8	.27	.54	.81	.09	.36	.63	.90	.17	.44	6.3	2.6	48.9	5.2	81.5
9	.27	.53	.79	.06	.32	.59	.86	.12	.38	5.9	1.8	7.7	3.6	79.5
49 10	20.26	40.52	60.77	81.03	101.29	121.55	141.81	162.07	182.32	1215.5	2431.0	3646.5	4862.0	6077.5
11	.25	.50	.75	1.01	.26	.51	.76	2.01	.26	5.1	30.2	5.3	60.3	5.4
12	.24	.49	.73	0.98	.22	.47	.71	1.96	.20	4.7	29.4	4.0	58.7	3.4
13	.24	.48	.71	.95	.19	.43	.67	.90	.14	4.3	8.5	2.8	7.1	71.3
14	.23	.46	.69	.92	.15	.39	.62	.85	.08	3.9	7.7	1.6	5.4	69.3
49 15	20.22	40.45	60.67	80.90	101.12	121.35	141.57	161.79	182.02	1213.5	2426.9	3640.4	4853.8	6067.3
16	.22	.43	.65	.87	.09	.30	.52	.74	1.95	3.0	6.1	39.1	2.2	5.2
17	.21	.42	.63	.84	.05	.26	.47	.68	.89	2.6	5.3	7.9	50.5	3.2
18	.20	.41	.61	.81	1.02	.22	.43	.63	.83	2.2	4.4	6.7	48.9	61.1
19	.20	.39	.59	.79	0.98	.18	.38	.58	.77	1.8	3.6	5.5	7.3	59.1
49 20	20.19	40.38	60.57	80.76	100.95	121.14	141.33	161.52	181.71	1211.4	2422.8	3634.2	4845.6	6057.1
21	.18	.37	.55	.73	.92	.10	.28	.47	.65	1.0	2.0	3.0	4.0	5.0
22	.18	.35	.53	.71	.88	.06	.23	.41	.59	0.6	1.2	1.8	2.4	3.0
23	.17	.34	.51	.68	.85	1.02	.19	.36	.53	10.2	20.3	30.5	40.7	50.9
24	.16	.33	.49	.65	.81	0.98	.14	.30	.47	09.8	19.5	29.3	39.1	48.9
49 25	20.16	40.31	60.47	80.62	100.78	120.94	141.09	161.25	181.41	1209.4	2418.7	3628.1	4837.4	6046.8
26	.15	.30	.45	.60	.75	.90	1.04	.19	.34	9.0	7.9	6.9	5.8	4.8
27	.14	.28	.43	.57	.71	.85	0.99	.14	.28	8.5	7.1	5.6	4.2	2.7
28	.14	.27	.41	.54	.68	.81	.95	.08	.22	8.1	6.2	4.4	2.5	40.7
29	.13	.26	.39	.51	.64	.77	.90	1.03	.16	7.7	5.4	3.2	30.9	38.6
49 30	20.12	40.24	60.37	80.49	100.61	120.73	140.85	160.98	181.10	1207.3	2414.6	3621.9	4829.3	6036.6
31	.11	.23	.35	.46	.58	.69	.80	.92	1.04	6.9	3.8	20.7	7.6	4.5
32	.11	.22	.33	.43	.54	.65	.75	.87	0.98	6.5	3.0	19.5	6.0	2.5
33	.10	.20	.30	.40	.51	.61	.71	.81	.91	6.1	2.1	8.2	4.3	30.4
34	.09	.19	.28	.38	.47	.57	.66	.76	.85	5.7	1.3	7.0	2.7	28.4
49 35	20.09	40.18	60.26	80.35	100.44	120.53	140.61	160.70	180.79	1205.3	2410.5	3615.8	4821.0	6026.3
36	.08	.16	.24	.32	.41	.49	.56	.65	.73	4.9	09.7	4.5	19.4	4.3
37	.07	.15	.22	.30	.37	.44	.51	.59	.67	4.4	8.9	3.3	7.8	2.2
38	.07	.13	.20	.27	.34	.40	.47	.54	.60	4.0	8.0	2.1	6.1	20.1
39	.06	.12	.18	.24	.30	.36	.42	.48	.54	3.6	7.2	10.9	4.5	18.1
49 40	20.05	40.11	60.16	80.21	100.27	120.32	140.37	160.43	180.48	1203.2	2406.4	3609.6	4812.8	6016.0
41	.05	.09	.14	.19	.24	.28	.32	.37	.42	2.8	5.6	8.4	11.2	4.0
42	.04	.08	.12	.16	.20	.24	.27	.32	.36	2.4	4.8	7.2	09.5	11.9
43	.03	.07	.10	.13	.17	.20	.23	.26	.29	2.0	3.9	5.9	7.9	09.9
44	.03	.05	.08	.10	.13	.16	.18	.21	.23	1.6	3.1	4.7	6.2	7.8
49 45	20.02	40.04	60.06	80.08	100.10	120.12	140.13	160.15	180.17	1201.2	2402.3	3603.4	4804.6	6005.8
46	.01	.02	.04	.05	.06	.07	.08	.10	.11	0.7	1.5	2.2	3.0	3.7
47	.01	.01	.02	80.02	100.02	20.03	40.03	60.04	80.05	200.3	400.7	601.0	801.3	6001.6
48	20.00	40.00	60.00	79.99	99.99	19.99	39.99	59.99	79.98	199.9	399.8	599.7	799.7	5999.6
49	19.99	39.98	59.97	.97	.95	.95	.94	.93	.92	9.5	9.0	8.5	8.0	7.5
49 50	19.98	39.97	59.95	79.94	99.92	119.91	139.89	159.88	179.86	1199.1	2398.2	3597.3	4796.4	5995.5
51	.98	.96	.93	.91	.89	.87	.84	.82	.80	8.7	7.4	6.0	4.7	3.4
52	.97	.94	.91	.89	.85	.83	.80	.77	.74	8.3	6.6	4.8	3.1	91.3
53	.96	.93	.89	.86	.82	.79	.75	.71	.68	7.9	5.7	3.6	91.4	89.3
54	.96	.91	.87	.83	.78	.74	.70	.66	.61	7.4	4.9	2.3	89.8	7.2
49 55	19.95	39.90	59.85	79.80	99.75	119.70	139.65	159.60	179.55	1197.0	2394.1	3591.1	4788.1	5985.1
56	.94	.89	.83	.78	.72	.66	.60	.55	.49	6.6	3.3	89.9	6.5	3.1
57	.94	.87	.81	.75	.68	.62	.55	.49	.43	6.2	2.4	8.6	4.8	81.0
58	.93	.86	.79	.72	.65	.58	.51	.44	.37	5.8	1.6	7.4	3.2	79.0
59	.92	.85	.77	.69	.61	.54	.46	.38	.30	5.4	90.7	6.1	81.5	6.9
49 60	19.92	39.83	59.75	79.66	99.58	119.50	139.41	159.33	179.24	1195.0	2389.9	3584.9	4779.9	5974.8

Lat.	Latitude 49° to 50°—Meridional arcs.						Latitude 49°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
49 00	30.892			1853.50					
1	2	1	30.89	.50	1	1 853.5	0 1	1 219.6	0.1
2	2	2	61.79	.51	2	3 707.0	2	2 439.1	0.5
3	2	3	92.68	.51	3	5 560.5	3	3 658.7	1.2
4	2	4	123.58	.52	4	7 414.0	4	4 878.3	2.1
49 05	30.892	5	154.47	1853.52	5	9 267.5	0 5	6 097.9	3.3
6	2	6	185.37	.53	6	11 121.1	6	7 317.5	4.8
7	2	7	216.26	.53	7	12 974.6	7	8 537.0	6.6
8	2	8	247.15	.54	8	14 828.1	8	9 756.6	8.6
9	2	9	278.05	.54	9	16 681.7	9	10 976.2	10.8
49 10	30.892	10	308.94	1853.55	10	18 535.2	0 10	12 195.8	13.4
11	3	1	339.84	.55	1	20 388.8	15	18 293.6	30.1
12	3	2	370.73	.56	2	22 242.3	20	24 391.3	53.5
13	3	3	401.63	.57	3	24 095.9	25	30 489.1	83.7
14	3	4	432.52	.57	4	25 949.5	30	36 586.8	120.5
49 15	30.893	15	463.41	1853.58	15	27 803.0	0 35	42 684.5	164.0
16	3	6	494.31	.58	6	29 656.6	40	48 782.1	214.2
17	3	7	525.20	.59	7	31 510.2	45	54 879.7	271.1
18	3	8	556.10	.59	8	33 363.8	50	60 977.2	334.7
19	3	9	586.99	.60	9	35 217.4	55	67 074.7	404.9
49 20	30.893	20	617.89	1853.60	20	37 071.0	1 00	73 172.0	481.9
21	3	1	648.78	.61	1	38 924.6	05	79 269.3	565.6
22	4	2	679.67	.61	2	40 778.2	10	85 366.5	656.0
23	4	3	710.57	.62	3	42 631.8	15	91 463.6	753.0
24	4	4	741.46	.63	4	44 485.4	20	97 560.5	856.7
49 25	30.894	25	772.36	1853.63	25	46 339.1	1 25	103 657.4	967.2
26	4	6	803.25	.64	6	48 192.7	30	109 754.1	1 084.3
27	4	7	834.15	.64	7	50 046.3	35	115 850.7	1 208.1
28	4	8	865.04	.65	8	51 900.0	40	121 947.1	1 338.6
29	4	9	895.93	.65	9	53 753.6	45	128 043.4	1 475.9
49 30	30.894	30	926.83	1853.66	30	55 607.3	1 50	134 139.6	1 619.8
31	4	1	957.72	.66	1	57 461.0	55	140 235.5	1 770.4
32	4	2	988.62	.67	2	59 314.6	2 00	146 331	1 928
33	5	3	1 019.51	.67	3	61 168.3	3 00	219 465	4 337
34	5	4	1 050.41	.68	4	63 022.0	4 00	292 561	7 709
49 35	30.895	35	1 081.30	1853.69	35	64 875.7	5 00	365 606	12 044
36	5	6	1 112.19	.69	6	66 729.4	6 00	438 588	17 340
37	5	7	1 143.09	.70	7	68 583.0	7 00	511 493	23 598
38	5	8	1 173.98	.70	8	70 436.7	8 00	584 310	30 815
39	5	9	1 204.88	.71	9	72 290.4	9 00	657 026	38 991
49 40	30.895	40	1 235.77	1853.71	40	74 144.2	10 00	729 627	48 123
41	5	1	1 266.67	.72	1	75 9[illegible].9	11 00	802 102	58 212
42	5	2	1 297.56	.72	2	77 851.6	12 00	874 438	69 254
43	5	3	1 328.46	.73	3	79 705.3	13 00	946 622	81 248
44	6	4	1 359.35	.73	4	81 559.1	14 00	1 018 642	94 191
49 45	30.896	45	1 390.24	1853.74	45	83 412.8	15 00	1 090 485	108 082
46	6	6	1 421.14	.75	6	85 266.5	16 00	1 162 138	122 918
47	6	7	1 452.03	.75	7	87 120.3	17 00	1 233 591	138 697
48	6	8	1 482.93	.76	8	88 974.0	18 00	1 304 829	155 416
49	6	9	1 513.82	.76	9	90 827.8	19 00	1 375 840	173 071
49 50	30.896	50	1 544.72	1853.77	50	92 681.6	20 00	1 446 613	191 660
51	6	1	1 575.61	.77	1	94 535.3	21 00	1 517 135	211 180
52	6	2	1 606.50	.78	2	96 389.1	22 00	1 587 394	231 627
53	6	3	1 637.40	.78	3	98 242.9	23 00	1 657 378	252 998
54	6	4	1 668.29	.79	4	100 096.7	24 00	1 727 073	275 288
49 55	30.897	55	1 699.19	1853.79	55	101 950.5	25 00	1 796 470	298 495
56	7	6	1 730.08	.80	6	103 804.3	26 00	1 865 554	322 614
57	7	7	1 760.98	.80	7	105 658.1	27 00	1 934 315	347 640
58	7	8	1 791.87	.81	8	107 511.9	28 00	2 002 740	373 570
59	7	9	1 822.76	.82	9	109 365.7	29 00	2 070 817	400 399
49 60	30.897	60	1 853.66	1853.82	60	111 219.5	30 00	2 138 536	428 123

Latitude 50° to 51°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
50 00	19.92	39.83	59.75	79.66	99.58	119.50	139.41	159.33	179.24	1195.0	2389.9	3584.9	4779.9	5974.8
1	.91	.82	.73	.64	.55	.46	.36	.27	.18	4.6	9.1	3.7	8.2	2.8
2	.90	.80	.71	.61	.51	.41	.31	.22	.12	4.1	8.3	2.4	6.6	70.7
3	.90	.79	.69	.58	.48	.37	.27	.16	9.06	3.7	7.4	81.2	4.9	68.6
4	.89	.78	.67	.55	.44	.33	.22	.11	9.00	3.3	6.6	79.9	3.2	6.6
50 05	19.88	39.76	59.64	79.53	99.41	119.29	139.17	159.05	178.93	1192.9	2385.8	3578.7	4771.6	5964.5
6	.87	.75	.62	.50	.38	.25	.12	9.00	.87	2.5	5.0	7.5	69.9	2.4
7	.87	.74	.60	.47	.34	.21	.07	8.94	.81	2.1	4.2	6.2	8.3	60.4
8	.86	.72	.58	.44	.31	.17	9.03	.89	.75	1.7	3.3	5.0	6.6	58.3
9	.85	.71	.56	.42	.27	.12	8.98	.83	.68	1.2	2.5	3.7	5.0	6.2
50 10	19.85	39.69	59.54	79.39	99.24	119.08	138.93	158.78	178.62	1190.8	2381.7	3572.5	4763.3	5954.2
11	.84	.68	.52	.36	.21	.04	.88	.72	.56	0.4	0.8	1.3	1.7	2.1
12	.83	.67	.50	.33	.17	9.00	.83	.67	.50	90.0	80.0	70.0	60.0	50.0
13	.83	.65	.48	.31	.14	8.96	.79	.61	.44	89.6	79.2	68.8	58.3	47.9
14	.82	.64	.46	.28	.10	.92	.74	.56	.37	9.2	8.3	7.5	6.7	5.9
50 15	19.81	39.63	59.44	79.25	99.07	118.88	138.69	158.50	178.31	1188.8	2377.5	3566.3	4755.0	5943.8
16	.81	.61	.42	.22	.03	.83	.64	.45	.25	8.3	6.7	5.0	3.4	41.7
17	.80	.60	.40	.20	9.00	.79	.59	.39	.19	7.9	5.9	3.8	1.7	39.6
18	.79	.58	.38	.17	8.96	.75	.55	.34	.13	7.5	5.0	2.5	50.1	7.6
19	.79	.57	.35	.14	.93	.71	.50	.28	.06	7.1	4.2	1.3	48.4	5.5
50 20	19.78	39.56	59.33	79.11	98.89	118.67	138.45	158.22	178.00	1186.7	2373.4	3560.1	4746.7	5933.4
21	.77	.54	.31	.09	.86	.63	.40	.17	7.94	6.3	2.6	58.8	5.1	31.4
22	.76	.53	.29	.06	.82	.59	.35	.11	.88	5.9	1.7	7.6	3.4	29.3
23	.76	.51	.27	.03	.79	.54	.30	.06	.81	5.4	0.9	6.3	1.8	7.2
24	.75	.50	.25	9.00	.75	.50	.25	8.00	.75	5.0	70.0	5.1	40.1	5.1
50 25	19.74	39.49	59.23	78.97	98.72	118.46	138.21	157.95	177.69	1184.6	2369.2	3553.8	4738.4	5923.0
26	.74	.47	.21	.95	.68	.42	.16	.89	.63	4.2	8.4	2.6	6.8	21.0
27	.73	.46	.19	.92	.65	.38	.11	.84	.57	3.8	7.6	1.3	5.1	18.9
28	.72	.45	.17	.89	.61	.34	.06	.78	.50	3.4	6.7	50.1	3.4	6.8
29	.71	.43	.15	.86	.58	.29	8.01	.73	.44	2.9	5.9	48.8	1.8	4.7
50 30	19.71	39.42	59.13	78.84	98.54	118.25	137.96	157.67	177.38	1182.5	2365.1	3547.6	4730.1	5912.6
31	.70	.40	.11	.81	.51	.21	.91	.61	.32	2.1	4.2	6.3	28.4	10.6
32	.70	.39	.09	.78	.47	.17	.86	.56	.25	1.7	3.4	5.1	6.8	08.5
33	.69	.38	.06	.75	.44	.13	.82	.50	.19	1.3	2.6	3.8	5.1	6.4
34	.68	.36	.04	.72	.40	.09	.77	.45	.13	0.9	1.7	2.6	3.5	4.3
50 35	19.67	39.35	59.02	78.70	98.37	118.04	137.72	157.39	177.06	1180.4	2360.9	3541.3	4721.8	5902.2
36	.67	.33	9.00	.67	.34	8.00	.67	.34	7.00	80.0	60.1	40.1	20.1	900.1
37	.66	.32	8.98	.64	.30	7.96	.62	.28	6.94	79.6	59.2	38.8	18.5	898.1
38	.65	.31	.96	.61	.27	.92	.58	.23	.88	9.2	8.4	7.6	6.8	6.0
39	.65	.29	.94	.58	.23	.88	.53	.17	.81	8.8	7.5	6.3	5.1	3.9
50 40	19.64	39.28	58.92	78.56	98.20	117.84	137.48	157.12	176.75	1178.4	2356.7	3535.1	4713.5	5891.8
41	.63	.26	.90	.53	.16	.79	.43	.06	.69	7.9	5.9	3.8	1.8	89.7
42	.63	.25	.88	.50	.13	.75	.38	7.00	.63	7.5	5.1	2.6	10.1	7.6
43	.62	.24	.86	.47	.10	.71	.33	6.95	.56	7.1	4.2	1.3	08.4	5.5
44	.61	.22	.84	.45	.06	.67	.28	.89	.50	6.7	3.4	30.1	6.8	3.5
50 45	19.60	39.21	58.81	78.42	98.03	117.63	137.24	156.84	176.44	1176.3	2352.6	3528.8	4705.1	5881.4
46	.60	.20	.79	.39	7.99	.59	.19	.78	.38	5.9	1.7	7.6	3.4	79.3
47	.59	.18	.77	.36	.95	.54	.14	.73	.32	5.4	0.9	6.3	1.8	7.2
48	.58	.17	.75	.34	.92	.50	.09	.67	.25	5.0	50.1	5.1	700.1	5.1
49	.58	.15	.73	.31	.89	.46	7.04	.61	.19	4.6	49.2	3.8	698.4	3.0
50 50	19.57	39.14	58.71	78.28	97.85	117.42	136.99	156.56	176.13	1174.2	2348.4	3522.6	4696.7	5870.9
51	.56	.13	.69	.25	.82	.38	.94	.50	.07	3.8	7.6	1.3	5.1	68.8
52	.56	.11	.67	.22	.78	.33	.89	.45	6.00	3.3	6.7	20.0	3.4	6.7
53	.55	.10	.65	.20	.75	.29	.84	.39	5.94	2.9	5.9	18.8	1.7	4.6
54	.54	.08	.63	.17	.71	.25	.79	.33	.88	2.5	5.0	7.5	90.0	2.6
50 55	19.53	39.07	58.60	78.14	97.68	117.21	136.75	156.28	175.81	1172.1	2344.2	3516.3	4688.4	5860.5
56	.53	.06	.58	.11	.64	.17	.70	.22	.75	1.7	3.4	5.0	6.7	58.4
57	.52	.04	.56	.08	.61	.13	.65	.17	.69	1.3	2.5	3.8	5.0	6.3
58	.51	.03	.54	.06	.57	.08	.60	.11	.63	0.8	1.7	2.5	3.3	4.2
59	.51	.01	.52	.03	.54	.04	.55	.06	.56	0.4	0.8	1.3	1.7	2.1
50 60	19.50	39.00	58.50	78.00	97.50	117.00	136.50	156.00	175.50	1170.0	2340.0	3510.0	4680.0	5850.0

Lat.		Latitude 50° to 51°—Meridional arcs.						Latitude 50°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
50	00	30.897			1853.82						
	1	7	1	30.90	.83	1	1 853.8	0	1	1 195.0	0.1
	2	7	2	61.80	.83	2	3 707.7		2	2 389.9	0.5
	3	7	3	92.70	.84	3	5 561.5		3	3 584.9	1.2
	4	7	4	123.60	.84	4	7 415.3		4	4 779.9	2.1
50	05	30.897	5	154.50	1853.85	5	9 269.2	0	5	5 974.8	3.3
	6	8	6	185.40	.85	6	11 123.0		6	7 169.8	4.8
	7	8	7	216.30	.86	7	12 976.9		7	8 364.8	6.5
	8	8	8	247.20	.86	8	14 830.7		8	9 559.7	8.5
	9	8	9	278.10	.87	9	16 684.6		9	10 754.7	10.8
50	10	30.898	10	309.00	1853.88	10	18 538.5	0	10	11 949.7	13.3
	11	8	1	339.90	.88	1	20 392.4		15	17 924.5	30.0
	12	8	2	370.80	.89	2	22 246.2		20	23 899.3	53.3
	13	8	3	401.70	.89	3	24 100.1		25	29 874.1	83.2
	14	8	4	432.60	.90	4	25 954.0		30	35 848.8	119.8
50	15	30.898	15	463.50	1853.90	15	27 807.9	0	35	41 823.5	163.1
	16	8	6	494.40	.91	6	29 661.8		40	47 798.1	213.0
	17	9	7	525.30	.91	7	31 515.7		45	53 772.7	269.6
	18	9	8	556.19	.92	8	33 369.7		50	59 747.2	332.8
	19	9	9	587.09	.92	9	35 223.6		55	65 721.6	402.8
50	20	30.899	20	617.99	1853.93	20	37 077.5	1	00	71 696.0	479.3
	21	9	1	648.89	.93	1	38 931.4		05	77 670.2	562.5
	22	9	2	679.79	.94	2	40 785.4		10	83 644.4	652.4
	23	9	3	710.69	.95	3	42 639.3		15	89 618.5	748.9
	24	9	4	741.59	.95	4	44 493.3		20	95 592.4	852.1
50	25	30.899	25	772.49	1853.96	25	46 347.2	1	25	101 566.2	961.9
	26	9	6	803.39	.96	6	48 201.2		30	107 540.0	1 078.4
	27	899	7	834.29	.97	7	50 055.2		35	113 513.5	1 201.5
	28	900	8	865.19	.97	8	51 909.1		40	119 486.9	1 331.3
	29	0	9	896.09	.98	9	53 763.1		45	125 460.2	1 467.8
50	30	30.900	30	926.99	1853.98	30	55 617.1	1	50	131 433.3	1 610.9
	31	0	1	957.89	.99	1	57 471.0		55	137 406.3	1 760.7
	32	0	2	988.79	3.99	2	59 325.0	2	00	143 379	1 917
	33	0	3	1 019.69	4.00	3	61 179.0	3	00	215 037	4 313
	34	0	4	1 050.59	.00	4	63 033.0	4	00	286 656	7 667
50	35	30.900	35	1 081.49	1854.01	35	64 887.0	5	00	358 224	11 978
	36	0	6	1 112.39	.02	6	66 741.1	6	00	429 727	17 246
	37	0	7	1 143.29	.02	7	68 595.1	7	00	501 154	23 469
	38	0	8	1 174.19	.03	8	70 449.1	8	00	572 492	30 646
	39	1	9	1 205.09	.03	9	72 303.2	9	00	643 727	38 777
50	40	30.901	40	1 235.99	1854.04	40	74 157.2	10	00	714 847	47 859
	41	1	1	1 266.89	.04	1	76 011.2	11	00	785 839	57 891
	42	1	2	1 297.79	.05	2	77 865.2	12	00	856 691	68 872
	43	1	3	1 328.69	.05	3	79 719.3	13	00	927 389	80 798
	44	1	4	1 359.59	.06	4	81 573.4	14	00	997 922	93 669
50	45	30.901	45	1 390.49	1854.06	45	83 427.4	15	00	1 068 277	107 482
	46	1	6	1 421.39	.07	6	85 281.5	16	00	1 138 440	122 234
	47	1	7	1 452.29	.07	7	87 135.6	17	00	1 208 400	137 923
	48	1	8	1 483.19	.08	8	88 989.6	18	00	1 278 144	154 546
	49	1	9	1 514.09	.09	9	90 843.7	19	00	1 347 660	172 099
50	50	30.902	50	1 544.99	1854.09	50	92 697.8	20	00	1 416 934	190 581
	51	2	1	1 575.89	.10	1	94 551.9	21	00	1 485 956	209 987
	52	2	2	1 606.79	.10	2	96 406.0	22	00	1 554 711	230 314
	53	2	3	1 637.69	.11	3	98 260.1	23	00	1 623 189	251 559
	54	2	4	1 668.58	.11	4	100 114.2	24	00	1 691 377	273 717
50	55	30.902	55	1 699.48	1854.12	55	101 968.4	25	00	1 759 262	296 785
	56	2	6	1 730.38	.12	6	103 822.5	26	00	1 826 833	320 758
	57	2	7	1 761.28	.13	7	105 676.6	27	00	1 894 077	345 633
	58	2	8	1 792.18	.13	8	107 530.7	28	00	1 960 983	371 404
	59	2	9	1 823.08	.14	9	109 384.9	29	00	2 027 538	398 068
50	60	30.902	60	1 853.98	1854.14	60	111 239.0	30	00	2 093 731	425 619

Latitude 51° to 52°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
51 00	19.50	39.00	58.50	78.00	97.50	117.00	136.50	156.00	175.50	1170.0	2340.0	3510.0	4680.0	5850.0
1	.49	8.99	.48	7.97	.47	6.96	.45	5.94	.44	69.6	39.2	08.7	78.3	47.9
2	.49	.97	.46	.94	.43	.92	.40	.89	.37	9.2	8.3	7.5	6.6	5.8
3	.48	.96	.44	.92	.40	.87	.35	.83	.31	8.7	7.5	6.2	5.0	3.7
4	.47	.94	.42	.89	.36	.83	.30	.78	.25	8.3	6.6	5.0	3.3	41.6
51 05	19.47	38.93	58.39	77.86	97.33	116.79	136.26	155.72	175.18	1167.9	2335.8	3503.7	4671.6	5839.5
6	.46	.92	.37	.83	.29	.75	.21	.66	.12	7.5	5.0	2.4	69.9	7.4
7	.45	.90	.35	.80	.26	.71	.16	.61	.06	7.1	4.1	501.2	8.2	5.3
8	.44	.89	.33	.78	.22	.66	.11	.55	5.00	6.6	3.3	499.9	6.6	3.2
9	.44	.87	.31	.75	.19	.62	.06	.50	4.93	6.2	2.4	8.7	4.9	31.1
51 10	19.43	38.86	58.29	77.72	97.15	116.58	136.01	155.44	174.87	1165.8	2331.6	3497.4	4663.2	5829.0
11	.42	.85	.27	.69	.12	.54	5.96	.38	.81	5.4	30.8	6.1	61.5	6.9
12	.42	.83	.25	.66	.08	.50	.91	.33	.74	5.0	29.9	4.9	59.8	4.8
13	.41	.82	.23	.64	.05	.45	.86	.27	.68	4.5	9.1	3.6	8.2	2.7
14	.40	.80	.21	.61	7.01	.41	.81	.22	.62	4.1	8.2	2.4	6.5	20.6
51 15	19.40	38.79	58.18	77.58	96.98	116.37	135.77	155.16	174.55	1163.7	2327.4	3491.1	4654.8	5818.5
16	.39	.78	.16	.55	.94	.33	.72	.10	.49	3.3	6.6	89.8	3.1	6.4
17	.38	.76	.14	.52	.91	.29	.67	5.05	.43	2.9	5.7	8.6	51.4	4.3
18	.37	.75	.12	.50	.87	.24	.62	4.99	.37	2.4	4.9	7.3	49.7	2.2
19	.37	.73	.10	.47	.84	.20	.57	.94	.30	2.0	4.0	6.0	8.1	10.1
51 20	19.36	38.72	58.08	77.44	96.80	116.16	135.52	154.88	174.24	1161.6	2323.2	3484.8	4646.4	5808.0
21	.35	.71	.06	.41	.77	.12	.47	.82	.18	1.2	2.4	3.5	4.7	5.9
22	.35	.69	.04	.38	.73	.08	.42	.77	.11	0.8	1.5	2.3	3.0	3.8
23	.34	.68	.02	.36	.70	6.03	.37	.71	4.05	60.3	20.7	81.0	41.3	801.7
24	.33	.66	8.00	.33	.66	5.99	.32	.65	3.99	59.9	19.8	79.7	39.6	799.5
51 25	19.32	38.65	57.97	77.30	96.63	115.95	135.28	154.60	173.92	1159.5	2319.0	3478.5	4638.0	5797.4
26	.32	.64	.95	.27	.59	.91	.23	.54	.86	9.1	8.2	7.2	6.3	5.3
27	.31	.62	.93	.24	.55	.86	.18	.49	.80	8.6	7.3	5.9	4.6	3.2
28	.30	.61	.91	.22	.52	.82	.13	.43	.74	8.2	6.5	4.7	2.9	91.1
29	.30	.59	.89	.19	.49	.78	.08	.37	.67	7.8	5.6	3.4	31.2	89.0
51 30	19.29	38.58	57.87	77.16	96.45	115.74	135.03	154.32	173.61	1157.4	2314.8	3472.1	4629.5	5786.9
31	.28	.57	.85	.13	.42	.70	4.98	.26	.55	7.0	3.9	70.9	7.8	4.8
32	.28	.55	.83	.10	.38	.65	.93	.20	.48	6.5	3.1	69.6	6.1	2.7
33	.27	.54	.81	.07	.35	.61	.88	.15	.42	6.1	2.2	8.3	4.4	80.6
34	.26	.52	.78	.05	.31	.57	.83	.09	.35	5.7	1.4	7.1	2.8	78.4
51 35	19.25	38.51	57.76	77.02	96.28	115.53	134.78	154.04	173.29	1155.3	2310.5	3465.8	4621.1	5776.3
36	.25	.49	.74	6.99	.24	.48	.73	3.98	.23	4.8	09.7	4.5	19.4	4.2
37	.24	.48	.72	.96	.21	.44	.68	.92	.16	4.4	8.8	3.3	7.7	2.1
38	.23	.47	.70	.93	.17	.40	.63	.87	.10	4.0	8.0	2.0	6.0	70.0
39	.23	.45	.68	.90	.14	.36	.58	.81	3.03	3.6	7.1	60.7	4.3	67.9
51 40	19.22	38.44	57.66	76.88	96.10	115.32	134.53	153.75	172.97	1153.2	2306.3	3459.5	4612.6	5765.8
41	.21	.42	.64	.85	.06	.27	.48	.70	.91	2.7	5.5	8.2	10.9	3.7
42	.21	.41	.62	.82	6.03	.23	.43	.64	.84	2.3	4.6	6.9	09.2	61.5
43	.20	.40	.59	.79	5.99	.19	.38	.58	.78	1.9	3.8	5.6	7.5	59.4
44	.19	.38	.57	.76	.96	.15	.33	.53	.72	1.5	2.9	4.4	5.8	7.3
51 45	19.18	38.37	57.55	76.74	95.92	115.10	134.29	153.47	172.65	1151.0	2302.1	3453.1	4604.1	5755.2
46	.18	.35	.53	.71	.88	.06	.24	.41	.59	0.6	1.2	1.8	2.4	3.1
47	.17	.34	.51	.68	.85	5.02	.19	.36	.53	50.2	300.4	50.6	600.8	50.9
48	.16	.33	.49	.65	.81	4.98	.14	.30	.47	49.8	299.5	49.3	599.1	48.8
49	.16	.31	.47	.62	.78	.93	.09	.25	.40	9.3	8.7	8.0	7.4	6.7
51 50	19.15	38.30	57.45	76.59	95.74	114.89	134.04	153.19	172.34	1148.9	2297.8	3446.8	4595.7	5744.6
51	.14	.28	.43	.57	.71	.85	3.99	.13	.28	8.5	7.0	5.5	4.0	2.5
52	.13	.27	.40	.54	.67	.81	.94	.08	.21	8.1	6.1	4.2	2.3	40.3
53	.13	.25	.38	.51	.64	.76	.89	3.02	.15	7.6	5.3	2.9	90.6	38.2
54	.12	.24	.36	.48	.60	.72	.84	2.96	.08	7.2	4.4	1.7	88.9	6.1
51 55	19.11	38.23	57.34	76.45	95.57	114.68	133.80	152.91	172.02	1146.8	2293.6	3440.4	4587.2	5734.0
56	.11	.21	.32	.42	.53	.64	.75	.85	1.96	6.4	2.7	39.1	5.5	31.8
57	.10	.20	.30	.40	.50	.59	.70	.79	.89	5.9	1.9	7.8	3.8	29.7
58	.09	.18	.28	.37	.46	.55	.65	.74	.83	5.5	1.0	6.6	2.1	7.6
59	.09	.17	.25	.34	.43	.51	.60	.68	.76	5.1	90.2	5.3	80.4	5.5
51 60	19.08	38.16	57.23	76.31	95.39	114.47	133.55	152.62	171.70	1144.7	2289.3	3434.0	4578.7	5723.4

Lat.		Latitude 51° to 52°—Meridional arcs.						Latitude 51°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
51	00	30.902			1854.14						
	1	3	1	30.91	.15	1	1 854.1	0	1	1 170.0	0.1
	2	3	2	61.81	.16	2	3 708.3		2	2 340.0	0.5
	3	3	3	92.72	.16	3	5 562.5		3	3 510.0	1.2
	4	3	4	123.62	.17	4	7 416.6		4	4 680.0	2.1
51	05	30.903	5	154.53	1854.17	5	9 270.8	0	5	5 850.0	3.3
	6	3	6	185.43	.18	6	11 125.0		6	7 020.0	4.8
	7	3	7	216.34	.18	7	12 979.1		7	8 190.0	6.5
	8	3	8	247.24	.19	8	14 833.3		8	9 360.0	8.5
	9	3	9	278.15	.19	9	16 687.5		9	10 530.0	10.7
51	10	30.903	10	309.05	1854.20	10	18 541.7	0	10	11 700.0	13.2
	11	3	1	339.96	.20	1	20 395.9		15	17 550.0	29.8
	12	3	2	370.86	.21	2	22 250.1		20	23 399.9	52.9
	13	4	3	401.77	.21	3	24 104.3		25	29 249.9	82.7
	14	4	4	432.67	.22	4	25 958.6		30	35 099.7	119.0
51	15	30.904	15	463.58	1854.23	15	27 812.8	0	35	40 949.6	162.0
	16	4	6	494.48	.23	6	29 667.0		40	46 799.4	211.6
	17	4	7	525.39	.24	7	31 521.2		45	52 649.1	267.8
	18	4	8	556.29	.24	8	33 375.5		50	58 498.8	330.6
	19	4	9	587.20	.25	9	35 229.7		55	64 348.4	400.0
51	20	30.904	20	618.10	1854.25	20	37 084.0	1	00	70 197.9	476.1
	21	4	1	649.01	.26	1	38 938.2		05	76 047.3	558.7
	22	4	2	679.91	.26	2	40 792.5		10	81 896.6	648.0
	23	4	3	710.82	.27	3	42 646.8		15	87 745.8	743.9
	24	5	4	741.72	.27	4	44 501.0		20	93 594.9	846.4
51	25	30.905	25	772.63	1854.28	25	46 355.3	1	25	99 443.9	955.5
	26	5	6	803.53	.28	6	48 209.6		30	105 292.8	1 071.2
	27	5	7	834.44	.29	7	50 063.9		35	111 141.5	1 193.5
	28	5	8	865.34	.29	8	51 918.2		40	116 990.1	1 322.4
	29	5	9	896.25	.30	9	53 772.5		45	122 838.5	1 458.0
51	30	30.905	30	927.15	1854.31	30	55 626.8	1	50	128 686.8	1 600.1
	31	5	1	958.06	.31	1	57 481.1		55	134 534.9	1 748.9
	32	5	2	988.96	.32	2	59 335.4	2	00	140 383	1 904
	33	5	3	1 019.87	.32	3	61 189.7	3	00	210 542	4 284
	34	5	4	1 050.77	.33	4	63 044.0	4	00	280 662	7 616
51	35	30.906	35	1 081.68	1854.33	35	64 898.4	5	00	350 731	11 898
	36	6	6	1 112.58	.34	6	66 752.7	6	00	420 735	17 130
	37	6	7	1 143.49	.34	7	68 607.0	7	00	490 662	23 311
	38	6	8	1 174.39	.35	8	70 461.4	8	00	560 499	30 440
	39	6	9	1 205.30	.35	9	72 315.7	9	00	630 232	38 515
51	40	30.906	40	1 236.20	1854.36	40	74 170.1	10	00	699 850	47 536
	41	6	1	1 267.11	.36	1	76 024.5	11	00	769 338	57 500
	42	6	2	1 298.01	.37	2	77 878.8	12	00	838 686	68 405
	43	6	3	1 328.92	.38	3	79 733.2	13	00	907 879	80 251
	44	6	4	1 359.82	.38	4	81 587.6	14	00	976 904	93 033
51	45	30.906	45	1 390.73	1854.39	45	83 442.0	15	00	1 045 751	106 751
	46	7	6	1 421.63	.39	6	85 296.3	16	00	1 114 404	121 401
	47	7	7	1 452.54	.40	7	87 150.7	17	00	1 182 853	136 981
	48	7	8	1 483.44	.40	8	89 005.1	18	00	1 251 084	153 488
	49	7	9	1 514.35	.41	9	90 859.5	19	00	1 319 085	170 919
51	50	30.907	50	1 545.25	1854.41	50	92 713.9	20	00	1 386 844	189 270
	51	7	1	1 576.16	.42	1	94 568.4	21	00	1 454 347	208 539
	52	7	2	1 607.06	.42	2	96 422.8	22	00	1 521 582	228 722
	53	7	3	1 637.97	.43	3	98 277.2	23	00	1 588 538	249 815
	54	7	4	1 668.88	.43	4	100 131.6	24	00	1 655 201	271 814
51	55	30.907	55	1 699.78	1854.44	55	101 986.1	25	00	1 721 561	294 715
	56	7	6	1 730.69	.44	6	103 840.5	26	00	1 787 603	318 514
	57	8	7	1 761.59	.45	7	105 695.0	27	00	1 853 316	343 206
	58	8	8	1 792.50	.46	8	107 549.4	28	00	1 918 688	368 788
	59	8	9	1 823.40	.46	9	109 403.9	29	00	1 983 708	395 254
51	60	30.908	60	1 854.31	1854.47	60	111 258.3	30	00	2 048 362	422 600

Latitude 52° to 53°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
52 00	19.08	38.16	57.23	76.31	95.39	114.47	133.55	152.62	171.70	1144.7	2289.3	3434.0	4578.7	5723.4
1	.07	.14	.21	.28	.36	.42	.50	.57	.64	4.2	8.5	2.7	7.0	21.2
2	.06	.13	.19	.25	.32	.38	.45	.51	.57	3.8	7.6	1.5	5.3	19.1
3	.06	.11	.17	.23	.29	.34	.40	.45	.51	3.4	6.8	30.2	3.6	7.0
4	.05	.10	.15	.20	.25	.30	.35	.40	.44	3.0	5.9	28.9	1.9	4.8
52 05	19.04	38.08	57.13	76.17	95.22	114.25	133.30	152.34	171.38	1142.5	2285.1	3427.6	4570.2	5712.7
6	.04	.07	.11	.14	.18	.21	.25	.28	.32	2.1	4.2	6.4	68.5	10.6
7	.03	.06	.08	.11	.14	.17	.20	.23	.25	1.7	3.4	5.1	6.8	08.5
8	.02	.04	.06	.08	.11	.13	.15	.17	.19	1.3	2.5	3.8	5.1	6.3
9	.01	.03	.04	.06	.07	.08	.10	.11	.12	0.8	1.7	2.5	3.4	4.2
52 10	19.01	38.01	57.02	76.03	95.04	114.04	133.05	152.06	171.06	1140.4	2280.8	3421.3	4561.7	5702.1
11	9.00	8.00	7.00	6.00	5.00	4.00	3.00	2.00	1.00	40.0	80.0	20.0	60.0	699.9
12	8.99	7.99	6.98	5.97	4.97	3.96	2.95	1.94	0.93	39.6	79.1	18.7	58.3	7.8
13	.99	.97	.96	.94	.93	.91	.90	.88	.87	9.1	8.3	7.4	6.5	5.7
14	.98	.96	.94	.91	.90	.87	.85	.83	.81	8.7	7.4	6.1	4.8	3.6
52 15	18.97	37.94	56.91	75.89	94.86	113.83	132.80	151.77	170.74	1138.3	2276.6	3414.9	4553.1	5691.4
16	.96	.93	.89	.86	.82	.79	.75	.71	.68	7.9	5.7	3.6	51.4	89.3
17	.96	.92	.87	.83	.79	.74	.70	.66	.61	7.4	4.9	2.3	49.7	7.2
18	.95	.90	.85	.80	.75	.70	.65	.60	.55	7.0	4.0	11.0	8.0	5.0
19	.94	.89	.83	.77	.72	.66	.60	.54	.48	6.6	3.2	09.7	6.3	2.9
52 20	18.94	37.87	56.81	75.74	94.68	113.62	132.55	151.49	170.42	1136.2	2272.3	3408.5	4544.6	5680.8
21	.93	.86	.79	.71	.64	.57	.50	.43	.36	5.7	1.4	7.2	2.9	78.6
22	.92	.84	.77	.69	.61	.53	.45	.37	.29	5.3	70.6	5.9	41.2	6.5
23	.91	.83	.74	.66	.57	.49	.40	.32	.23	4.9	69.7	4.6	39.5	4.3
24	.91	.81	.72	.63	.54	.44	.35	.26	.16	4.4	8.9	3.3	7.8	2.2
52 25	18.90	37.80	56.70	75.60	94.50	113.40	132.30	151.20	170.10	1134.0	2268.0	3402.0	4536.0	5670.1
26	.89	.79	.68	.57	.46	.36	.25	.14	70.04	3.6	7.2	400.8	4.3	67.9
27	.89	.77	.66	.54	.43	.32	.20	.09	69.97	3.2	6.3	399.5	2.6	5.8
28	.88	.76	.64	.52	.39	.27	.15	1.03	.91	2.7	5.5	8.2	30.9	3.7
29	.87	.74	.61	.49	.36	.23	.10	0.97	.84	2.3	4.6	6.9	29.2	61.5
52 30	18.86	37.73	56.59	75.46	94.32	113.19	132.05	150.92	169.78	1131.9	2263.8	3395.6	4527.5	5659.4
31	.86	.71	.57	.43	.29	.14	2.00	.86	.72	1.4	2.9	4.3	5.8	7.2
32	.85	.70	.55	.40	.25	.10	1.95	.80	.65	1.0	2.1	3.1	4.1	5.1
33	.84	.69	.53	.37	.22	.06	.90	.75	.59	0.6	1.2	1.8	2.4	2.9
34	.84	.67	.51	.35	.18	3.02	.85	.69	.52	30.2	60.3	90.5	20.6	50.8
52 35	18.83	37.66	56.49	75.32	94.15	112.97	131.80	150.63	169.46	1129.7	2259.5	3389.2	4518.9	5648.7
36	.82	.64	.46	.29	.11	.93	.75	.57	.40	9.3	8.6	7.9	7.2	6.5
37	.81	.63	.44	.26	.08	.89	.70	.52	.33	8.9	7.8	6.6	5.5	4.4
38	.81	.61	.42	.23	.04	.84	.65	.46	.27	8.4	6.9	5.3	3.8	2.2
39	.80	.60	.40	.20	4.01	.80	.60	.40	.20	8.0	6.1	4.1	2.1	40.1
52 40	18.79	37.59	56.38	75.17	93.97	112.76	131.55	150.35	169.14	1127.6	2255.2	3382.8	4510.4	5638.0
41	.79	.57	.36	.14	.93	.72	.50	.29	.08	7.2	4.3	1.5	508.6	5.8
42	.78	.56	.34	.12	.90	.67	.45	.23	9.01	6.7	3.5	80.2	6.9	3.7
43	.77	.54	.31	.09	.86	.63	.40	.17	8.95	6.3	2.6	78.9	5.2	31.5
44	.76	.53	.29	.06	.83	.59	.35	.12	.88	5.9	1.8	7.6	3.5	29.4
52 45	18.76	37.51	56.27	75.03	93.79	112.54	131.30	150.06	168.82	1125.4	2250.9	3376.3	4501.8	5627.2
46	.75	.50	.25	5.00	.75	.50	.25	50.00	.75	5.0	50.0	5.0	500.1	5.1
47	.74	.49	.23	4.97	.72	.46	.20	49.94	.69	4.6	49.2	3.8	498.3	2.9
48	.74	.47	.21	.94	.68	.42	.15	.89	.62	4.2	8.3	2.5	6.6	20.8
49	.73	.46	.19	.92	.65	.37	.10	.83	.56	3.7	7.5	71.2	4.9	18.6
52 50	18.72	37.44	56.16	74.89	93.61	112.33	131.05	149.77	168.49	1123.3	2246.6	3369.9	4493.2	5616.5
51	.71	.43	.14	.86	.57	.29	0.00	.72	.43	2.9	5.7	8.6	91.6	4.3
52	.71	.41	.12	.83	.54	.24	.95	.66	.36	2.4	4.9	7.3	89.7	2.2
53	.70	.40	.10	.80	.50	.20	.90	.60	.30	2.0	4.0	6.0	8.0	10.0
54	.69	.39	.08	.77	.47	.16	.85	.54	.23	1.6	3.2	4.7	6.3	07.9
52 55	18.69	37.37	56.06	74.74	93.43	112.11	130.80	149.49	168.17	1121.1	2242.3	3363.4	4484.6	5605.7
56	.68	.36	.03	.71	.39	.07	.75	.43	.10	0.7	1.4	2.1	2.9	3.4
57	.67	.34	6.01	.69	.36	2.03	.70	.37	8.04	20.3	40.6	60.9	81.1	601.4
58	.66	.33	5.99	.66	.32	1.99	.65	.31	7.98	19.9	39.7	59.6	79.4	599.3
59	.66	.31	.97	.63	.29	.94	.60	.26	.91	9.4	8.9	8.3	7.7	7.1
52 60	18.65	37.30	55.95	74.60	93.25	111.90	130.55	149.20	167.85	1119.0	2238.0	3357.0	4476.0	5595.0

Lat.		Latitude 52° to 53°—Meridional arcs.						Latitude 52°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X.	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
52	00	30.908			1854.47						
	1	8	1	30.91	.47	1	1 854.5	0	1	1 144.7	0.1
	2	8	2	61.82	.48	2	3 708.9		2	2 289.3	0.5
	3	8	3	92.73	.48	3	5 563.4		3	3 434.0	1.2
	4	8	4	123.64	.49	4	7 417.9		4	4 578.7	2.1
52	05	30.908	5	154.55	1854.49	5	9 272.4	0	5	5 723.4	3.3
	6	8	6	185.46	.50	6	11 126.9		6	6 868.0	4.7
	7	8	7	216.37	.50	7	12 981.4		7	8 012.7	6.4
	8	8	8	247.28	.51	8	14 835.9		8	9 157.4	8.4
	9	9	9	278.19	.51	9	16 690.4		9	10 302.0	10.6
52	10	30.909	10	309.10	1854.52	10	18 544.9	0	10	11 446.7	13.1
	11	9	1	340.01	.52	1	20 399.4		15	17 170.0	29.5
	12	9	2	370.93	.53	2	22 254.0		20	22 893.4	52.5
	13	9	3	401.84	.54	3	24 108.5		25	28 616.6	82.0
	14	9	4	432.75	.54	4	25 963.0		30	34 339.9	118.1
52	15	30.909	15	463.66	1854.55	15	27 817.6	0	35	40 063.1	160.7
	16	9	6	494.57	.55	6	29 672.1		40	45 786.3	209.9
	17	9	7	525.48	.56	7	31 526.7		45	51 509.4	265.7
	18	9	8	556.39	.56	8	33 381.3		50	57 232.4	328.0
	19	9	9	587.30	.57	9	35 235.8		55	62 955.3	396.9
52	20	30.910	20	618.21	1854.57	20	37 090.4	1	00	68 678.2	472.3
	21	0	1	649.12	.58	1	38 945.0		05	74 401.0	554.3
	22	0	2	680.03	.58	2	40 799.6		10	80 123.6	642.8
	23	0	3	710.94	.59	3	42 654.1		15	85 846.2	737.9
	24	0	4	741.85	.59	4	44 508.7		20	91 568.7	839.6
52	25	30.910	25	772.76	1854.60	25	46 363.3	1	25	97 291.0	947.8
	26	0	6	803.67	.60	6	48 217.9		30	103 013.2	1 062.6
	27	0	7	834.58	.61	7	50 072.5		35	108 735.3	1 184.0
	28	0	8	865.49	.62	8	51 927.2		40	114 457.2	1 311.9
	29	0	9	896.40	.62	9	53 781.8		45	120 179.0	1 446.3
52	30	30.910	30	927.31	1854.63	30	55 636.4	1	50	125 900.7	1 587.4
	31	1	1	958.22	.63	1	57 491.0		55	131 622.1	1 735.0
	32	1	2	989.13	.64	2	59 345.7	2	00	137 343	1 889
	33	1	3	1 020.04	.64	3	61 200.3	3	00	205 982	4 250
	34	1	4	1 050.95	.65	4	63 054.9	4	00	274 583	7 555
52	35	30.911	35	1 081.87	1854.65	35	64 909.6	5	00	343 131	11 803
	36	1	6	1 112.78	.66	6	66 764.2	6	00	411 615	16 993
	37	1	7	1 143.69	.66	7	68 618.9	7	00	480 020	23 124
	38	1	8	1 174.60	.67	8	70 473.6	8	00	548 335	30 196
	39	1	9	1 205.51	.67	9	72 328.2	9	00	616 546	38 207
52	40	30.911	40	1 236.42	1854.68	40	74 182.9	10	00	684 640	47 155
	41	1	1	1 267.33	.68	1	76 037.6	11	00	752 605	57 039
	42	1	2	1 298.24	.69	2	77 892.3	12	00	820 428	67 856
	43	2	3	1 329.15	.69	3	79 747.0	13	00	888 095	79 605
	44	2	4	1 360.06	.70	4	81 601.7	14	00	955 595	92 284
52	45	30.912	45	1 390.97	1854.71	45	83 456.4	15	00	1 022 913	105 890
	46	2	6	1 421.88	.71	6	85 311.1	16	00	1 090 038	120 420
	47	2	7	1 452.79	.72	7	87 165.8	17	00	1 156 957	135 872
	48	2	8	1 483.70	.72	8	89 020.5	18	00	1 223 658	152 243
	49	2	9	1 514.61	.73	9	90 875.3	19	00	1 290 126	169 530
52	50	30.912	50	1 545.52	1854.73	50	92 730.0	20	00	1 356 351	187 729
	51	2	1	1 576.43	.74	1	94 584.7	21	00	1 422 319	206 838
	52	2	2	1 607.34	.74	2	96 439.5	22	00	1 488 018	226 852
	53	2	3	1 638.25	.75	3	98 294.2	23	00	1 553 436	247 767
	54	3	4	1 669.16	.75	4	100 149.0	24	00	1 618 559	269 580
52	55	30.913	55	1 700.07	1854.76	55	102 003.7	25	00	1 683 377	292 287
	56	3	6	1 730.98	.76	6	103 858.5	26	00	1 747 876	315 883
	57	3	7	1 761.89	.77	7	105 713.3	27	00	1 812 045	340 364
	58	3	8	1 792.81	.77	8	107 568.0	28	00	1 875 870	365 725
	59	3	9	1 823.72	.78	9	109 422.8	29	00	1 939 342	391 961
52	60	30.913	60	1 854.63	1854.78	60	111 277.6	30	00	2 002 446	419 068

Latitude 53° to 54°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
53 00	18.65	37.30	55.95	74.60	93.25	111.90	130.55	149.20	167.85	1119.0	2238.0	3357.0	4476.0	5595.0
1	.64	.29	.93	.57	.21	.86	.50	.14	.79	8.6	7.1	5.7	4.2	2.8
2	.64	.27	.91	.54	.18	.81	.45	.08	.72	8.1	6.3	4.4	2.5	90.6
3	.63	.26	.88	.51	.14	.77	.40	9.03	.66	7.7	5.4	3.1	70.8	88.5
4	.62	.24	.86	.49	.11	.73	.35	8.97	.59	7.3	4.6	1.8	69.1	6.3
53 05	18.61	37.23	55.84	74.46	93.07	111.68	130.30	148.91	167.53	1116.8	2233.7	3350.5	4467.3	5584.2
6	.61	.21	.82	.43	.03	.64	.25	.85	.46	6.4	2.8	49.2	5.6	82.0
7	.60	.20	.80	.40	3.00	.60	.20	.80	.40	6.0	2.0	7.9	3.9	79.9
8	.59	.18	.78	.37	2.96	.55	.15	.74	.33	5.5	1.1	6.6	2.2	7.7
9	.59	.17	.75	.34	.93	.51	.10	.68	.27	5.1	30.2	5.3	60.4	5.5
53 10	18.58	37.16	55.73	74.31	92.89	111.47	130.05	148.62	167.20	1114.7	2229.4	3344.0	4458.7	5573.4
11	.57	.14	.71	.28	.85	.42	30.00	.57	.14	4.2	8.5	2.7	7.0	71.2
12	.56	.13	.69	.25	.82	.38	29.95	.51	.07	3.8	7.6	1.4	5.2	69.1
13	.56	.11	.67	.23	.78	.34	.90	.45	7.01	3.4	6.8	40.1	3.5	6.9
14	.55	.10	.65	.20	.75	.29	.85	.39	6.94	2.9	5.9	38.8	1.8	4.7
53 15	18.54	37.08	55.63	74.17	92.71	111.25	129.79	148.34	166.88	1112.5	2225.0	3337.5	4450.1	5562.6
16	.53	.07	.60	.14	.67	.21	.74	.28	.81	2.1	4.1	6.2	48.3	60.4
17	.53	.06	.58	.11	.64	.17	.69	.22	.75	1.7	3.3	5.0	6.6	58.3
18	.52	.04	.56	.08	.60	.12	.64	.16	.68	1.2	2.4	3.7	4.9	6.1
19	.51	.03	.54	.05	.57	.08	.59	.10	.62	0.8	1.6	2.4	3.1	3.9
53 20	18.51	37.01	55.52	74.02	92.53	111.04	129.54	148.05	166.55	1110.4	2220.7	3331.1	4441.4	5551.8
21	.50	7.00	.50	3.99	.49	0.99	.49	7.99	.49	09.9	19.8	29.8	39.7	49.6
22	.49	6.98	.47	.97	.46	.95	.44	.93	.42	9.5	9.0	8.5	8.0	7.4
23	.48	.97	.45	.94	.42	.91	.39	.87	.36	9.1	8.1	7.2	6.2	5.3
24	.48	.95	.43	.91	.39	.86	.34	.82	.29	8.6	7.3	5.9	4.5	3.1
53 25	18.47	36.94	55.41	73.88	92.35	110.82	129.29	147.76	166.23	1108.2	2216.4	3324.6	4432.8	5540.9
26	.46	.93	.39	.85	.31	.78	.24	.70	.16	7.8	5.5	3.3	31.0	38.8
27	.46	.91	.37	.82	.28	.73	.19	.64	.10	7.3	4.6	2.0	29.3	6.6
28	.45	.90	.34	.79	.24	.69	.14	.59	6.03	6.9	3.8	20.7	7.6	4.4
29	.44	.88	.32	.76	.21	.65	.09	.53	5.97	6.5	2.9	19.4	5.8	2.3
53 30	18.43	36.87	55.30	73.73	92.17	110.60	129.04	147.47	165.90	1106.0	2212.0	3318.1	4424.1	5530.1
31	.43	.85	.28	.70	.13	.56	8.99	.41	.84	5.6	1.2	6.8	2.3	27.9
32	.42	.84	.26	.68	.10	.52	.94	.35	.77	5.2	10.3	5.5	20.6	5.8
33	.41	.82	.24	.65	.06	.47	.89	.30	.71	4.7	09.4	4.2	18.9	3.6
34	.40	.81	.21	.62	2.03	.43	.84	.24	.64	4.3	8.6	2.9	7.1	21.4
53 35	18.40	36.80	55.19	73.59	91.99	110.39	128.78	147.18	165.58	1103.9	2207.7	3311.6	4415.4	5519.3
36	.39	.78	.17	.56	.95	.34	.73	.12	.51	3.4	6.8	10.2	3.7	7.1
37	.38	.77	.15	.53	.92	.30	.68	.06	.45	3.0	6.0	08.9	1.9	4.9
38	.38	.75	.13	.50	.88	.25	.63	7.01	.38	2.5	5.1	7.6	10.2	2.7
39	.37	.74	.11	.48	.85	.21	.58	6.95	.32	2.1	4.3	6.3	08.5	10.6
53 40	18.36	36.72	55.08	73.45	91.81	110.17	128.53	146.89	165.25	1101.7	2203.4	3305.0	4406.7	5508.4
41	.35	.71	.06	.42	.77	.12	.48	.83	.19	1.2	2.5	3.7	5.0	6.2
42	.35	.69	.04	.39	.74	.08	.43	.77	.12	0.8	1.6	2.4	3.2	4.0
43	.34	.68	.02	.36	.70	10.04	.38	.72	5.06	100.4	200.8	301.1	401.5	501.9
44	.33	.66	5.00	.33	.66	09.99	.33	.66	4.99	099.9	199.9	299.8	399.8	499.7
53 45	18.32	36.65	54.97	73.30	91.63	109.95	128.28	146.60	164.93	1099.5	2199.0	3298.5	4398.0	5497.5
46	.32	.64	.95	.27	.59	.91	.22	.54	.86	9.1	8.1	7.2	6.3	5.3
47	.31	.62	.93	.24	.55	.86	.17	.48	.80	8.6	7.3	5.9	4.5	3.2
48	.30	.61	.91	.21	.51	.82	.12	.43	.73	8.2	6.4	4.6	2.8	91.0
49	.30	.59	.89	.19	.48	.78	.07	.37	.67	7.8	5.6	3.3	1.1	88.8
53 50	18.29	36.58	54.87	73.16	91.44	109.73	128.02	146.31	164.60	1097.3	2194.7	3292.0	4389.3	5486.6
51	.28	.56	.85	.13	.40	.69	7.97	.25	.53	6.9	3.8	90.7	7.6	4.5
52	.27	.55	.82	.10	.37	.65	.92	.19	.47	6.5	2.9	89.4	5.8	2.3
53	.27	.53	.80	.07	.33	.60	.87	.14	.40	6.0	2.1	8.1	4.1	80.1
54	.26	.52	.78	.04	.30	.56	.82	.08	.34	5.6	1.2	6.7	2.3	77.9
53 55	18.25	36.50	54.76	73.01	91.26	109.51	127.76	146.02	164.27	1095.1	2190.3	3285.4	4380.6	5475.7
56	.25	.49	.74	2.98	.22	.47	.71	5.96	.21	4.7	89.4	4.1	78.8	3.6
57	.24	.48	.71	.95	.19	.43	.66	.90	.14	4.3	8.5	2.8	7.1	71.4
58	.23	.46	.69	.92	.15	.38	.61	.85	.07	3.8	7.7	1.5	5.4	69.2
59	.22	.45	.67	.89	.12	.34	.56	.79	4.01	3.4	6.8	80.2	3.6	7.0
53 60	18.22	36.43	54.65	72.86	91.08	109.30	127.51	145.73	163.94	1093.0	2185.9	3278.9	4371.9	5464.8

Lat.		Latitude 53° to 54°—Meridional arcs.						Latitude 53°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
53	00	30.913			1854.78						
	1	3	1	30.92	.79	1	1 854.8	0	1	1 119.0	0.1
	2	3	2	61.83	.80	2	3 709.6		2	2 238.0	0.5
	3	3	3	92.75	.80	3	5 564.4		3	3 357.0	1.2
	4	3	4	123.66	.81	4	7 419.2		4	4 476.0	2.1
53	05	30.914	5	154.58	1854.81	5	9 274.0	0	5	5 595.0	3.3
	6	4	6	185.49	.82	6	11 128.8		6	6 714.0	4.7
	7	4	7	216.41	.82	7	12 983.6		7	7 832.9	6.4
	8	4	8	247.33	.83	8	14 838.5		8	8 951.9	8.3
	9	4	9	278.24	.83	9	16 693.3		9	10 070.9	10.5
53	10	30.914	10	309.16	1854.84	10	18 548.1	1	10	11 189.9	13.0
	11	4	1	340.07	.84	1	20 403.0		15	16 784.9	29.2
	12	4	2	370.99	.85	2	22 257.8		20	22 379.8	52.0
	13	4	3	401.90	.85	3	24 112.7		25	27 974.7	81.2
	14	4	4	432.82	.86	4	25 967.5		30	33 569.5	117.0
53	15	30.914	15	463.74	1854.86	15	27 822.4	1	35	39 164.3	159.2
	16	4	6	494.65	.87	6	29 677.2		40	44 759.1	208.0
	17	5	7	525.57	.87	7	31 532.1		45	50 353.8	263.2
	18	5	8	556.48	.88	8	33 387.0		50	55 948.4	325.0
	19	5	9	587.40	.89	9	35 241.9		55	61 542.9	393.2
53	20	30.915	20	618.31	1854.89	20	37 096.8	1	00	67 137.4	467.9
	21	5	1	649.23	.90	1	38 951.7		05	72 731.7	549.2
	22	5	2	680.15	.90	2	40 806.6		10	78 326.0	636.9
	23	5	3	711.06	.91	3	42 661.5		15	83 920.2	731.1
	24	5	4	741.98	.91	4	44 516.4		20	89 514.2	831.8
53	25	30.915	25	772.89	1854.92	25	46 371.3	1	25	95 108.2	939.1
	26	5	6	803.81	.92	6	48 226.2		30	100 702.0	1 052.8
	27	5	7	834.72	.93	7	50 081.1		35	106 295.7	1 173.0
	28	6	8	865.64	.93	8	51 936.1		40	111 889.2	1 299.7
	29	6	9	896.56	.94	9	53 791.0		45	117 482.6	1 432.9
53	30	30.916	30	927.47	1854.94	30	55 645.9	1	50	123 075.8	1 572.6
	31	6	1	958.39	.95	1	57 500.9		55	128 668.9	1 718.9
	32	6	2	989.30	.95	2	59 355.8	2	00	134 262	1 872
	33	6	3	1 020.22	.96	3	61 210.8	3	00	201 360	4 211
	34	6	4	1 051.13	.96	4	63 065.8	4	00	268 419	7 485
53	35	30.916	35	1 082.05	1854.97	35	64 920.7	5	00	335 426	11 693
	36	6	6	1 112.97	.97	6	66 775.7	6	00	402 368	16 835
	37	6	7	1 143.88	.98	7	68 630.7	7	00	469 232	22 910
	38	6	8	1 174.80	.99	8	70 485.6	8	00	536 004	29 916
	39	7	9	1 205.71	4.99	9	72 340.6	9	00	602 672	37 852
53	40	30.917	40	1 236.63	1855.00	40	74 195.6	10	00	669 224	46 717
	41	7	1	1 267.54	.00	1	76 050.6	11	00	735 645	56 508
	42	7	2	1 298.46	.01	2	77 905.6	12	00	801 923	67 224
	43	7	3	1 329.38	.01	3	79 760.6	13	00	868 046	78 863
	44	7	4	1 360.29	.02	4	81 615.7	14	00	933 999	91 422
53	45	30.917	45	1 391.21	1855.02	45	83 470.7	15	00	999 772	104 900
	46	7	6	1 422.12	.03	6	85 325.7	16	00	1 065 350	119 293
	47	7	7	1 453.04	.03	7	87 180.7	17	00	1 130 721	134 598
	48	7	8	1 483.95	.04	8	89 035.8	18	00	1 195 872	150 813
	49	7	9	1 514.87	.04	9	90 890.8	19	00	1 260 791	167 935
53	50	30.917	50	1 545.79	1855.05	50	92 745.8	20	00	1 325 466	185 960
	51	8	1	1 576.70	.05	1	94 600.9	21	00	1 389 882	204 885
	52	8	2	1 607.62	.06	2	96 455.9	22	00	1 454 029	224 706
	53	8	3	1 638.53	.06	3	98 311.0	23	00	1 517 893	245 418
	54	8	4	1 669.45	.07	4	100 166.1	24	00	1 581 462	267 019
53	55	30.918	55	1 700.36	1855.07	55	102 021.1	25	00	1 644 724	289 504
	56	8	6	1 731.28	.08	6	103 876.2	26	00	1 707 666	312 869
	57	8	7	1 762.20	.08	7	105 731.3	27	00	1 770 277	337 109
	58	8	8	1 793.11	.09	8	107 586.4	28	00	1 832 544	362 219
	59	8	9	1 824.03	.10	9	109 441.5	20	00	1 894 455	388 194
53	60	30.918	60	1 854.94	1855.10	60	111 296.6	30	00	1 955 997	415 030

Latitude 54° to 55°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1″	2″	3″	4″	5″
° ′														
54 00	18.22	36.43	54.65	72.86	91.08	109.30	127.51	145.73	163.94	1093.0	2185.9	3278.9	4371.9	5464.8
1	.21	.42	.63	.83	.04	.25	.46	.67	.88	2.5	5.0	7.6	70.1	2.7
2	.20	.40	.61	.81	1.01	.21	.41	.61	.81	2.1	4.2	6.3	68.4	60.5
3	.19	.39	.58	.78	0.97	.17	.36	.55	.75	1.7	3.3	5.0	6.6	58.3
4	.19	.37	.56	.75	.94	.12	.31	.50	.68	1.2	2.5	3.7	4.9	6.1
54 05	18.18	36.36	54.54	72.72	90.90	109.08	127.25	145.44	163.61	1090.8	2181.6	3272.3	4363.1	5453.9
6	.17	.34	.52	.69	.86	9.03	.20	.38	.55	90.3	80.7	71.0	61.4	51.7
7	.16	.33	.50	.66	.83	8.99	.15	.32	.48	89.9	79.8	69.7	59.6	49.5
8	.16	.32	.47	.63	.79	.95	.10	.26	.42	9.5	9.0	8.4	7.9	7.4
9	.15	.30	.45	.60	.76	.90	.05	.20	.35	9.0	8.1	7.1	6.1	5.2
54 10	18.14	36.29	54.43	72.57	90.72	108.86	127.00	145.15	163.29	1088.6	2177.2	3265.8	4354.4	5443.0
11	.14	.27	.41	.54	.68	.82	6.95	.09	.22	8.2	6.3	4.5	2.6	40.8
12	.13	.26	.39	.51	.65	.77	.90	5.03	.16	7.7	5.4	3.2	50.9	38.6
13	.12	.24	.36	.49	.61	.73	.85	4.97	.09	7.3	4.6	1.8	49.1	6.4
14	.11	.23	.34	.46	.57	.68	.80	.91	3.03	6.8	3.7	60.5	7.4	4.2
54 15	18.10	36.21	54.32	72.43	90.54	108.64	126.74	144.85	162.96	1086.4	2172.8	3259.2	4345.6	5432.0
16	.10	.20	.30	.40	.50	.60	.69	.80	.89	6.0	1.9	7.9	3.9	29.8
17	.09	.18	.28	.37	.46	.55	.64	.74	.83	5.5	1.0	6.6	2.1	7.7
18	.08	.17	.25	.34	.42	.51	.59	.68	.76	5.1	70.2	5.3	40.4	5.5
19	.08	.16	.23	.31	.39	.47	.54	.62	.70	4.7	69.3	4.0	38.6	3.3
54 20	18.07	36.14	54.21	72.28	90.35	108.42	126.49	144.56	162.63	1084.2	2168.4	3252.7	4336.9	5421.1
21	.06	.13	.19	.25	.31	.38	.44	.50	.56	3.8	7.5	1.3	5.1	18.9
22	.06	.11	.17	.22	.28	.33	.39	.45	.50	3.3	6.7	50.0	3.4	6.7
23	.05	.10	.14	.19	.24	.29	.34	.39	.43	2.9	5.8	48.7	31.6	4.5
24	.04	.08	.12	.16	.21	.25	.29	.33	.37	2.5	4.9	7.4	29.8	2.3
54 25	18.03	36.07	54.10	72.13	90.17	108.20	126.23	144.27	162.30	1082.0	2164.0	3246.1	4328.1	5410.1
26	.03	.05	.08	.10	.13	.16	.18	.21	.23	1.6	3.1	4.8	6.3	07.9
27	.02	.04	.06	.08	.10	.11	.13	.15	.17	1.1	2.3	3.4	4.6	5.7
28	.01	.02	.03	.05	.06	.07	.08	.09	.10	0.7	1.4	2.1	2.8	3.5
29	.00	6.01	4.01	2.02	90.03	8.03	6.03	4.04	2.04	80.3	60.6	40.8	21.1	401.3
54 30	18.00	35.99	53.99	71.99	89.99	107.98	125.98	143.98	161.97	1079.8	2159.7	3239.5	4319.3	5399.1
31	7.99	.98	.97	.96	.95	.94	.93	.92	.91	9.4	8.8	8.2	7.6	6.9
32	.98	.96	.95	.93	.91	.89	.88	.86	.84	8.9	7.9	6.8	5.8	4.7
33	.98	.95	.92	.90	.88	.85	.83	.80	.78	8.5	7.0	5.5	4.0	2.5
34	.97	.94	.90	.87	.84	.81	.78	.74	.71	8.1	6.2	4.2	2.3	90.3
54 35	17.96	35.92	53.88	71.84	89.80	107.76	125.72	143.68	161.65	1077.6	2155.3	3232.9	4310.5	5388.1
36	.95	.91	.86	.81	.77	.72	.67	.63	.58	7.2	4.4	1.6	08.8	5.9
37	.95	.89	.84	.78	.73	.67	.62	.57	.51	6.7	3.5	30.2	7.0	3.7
38	.94	.88	.81	.75	.69	.63	.57	.51	.45	6.3	2.6	28.9	5.2	81.5
39	.93	.86	.79	.73	.66	.59	.52	.45	.38	5.9	1.8	7.6	3.5	79.4
54 40	17.92	35.85	53.77	71.70	89.62	107.54	125.47	143.39	161.32	1075.4	2150.9	3226.3	4301.7	5377.2
41	.92	.83	.75	.67	.58	.50	.42	.33	.25	5.0	50.0	5.0	300.0	4.9
42	.91	.82	.73	.64	.54	.45	.36	.27	.18	4.5	49.1	3.6	298.2	2.7
43	.90	.80	.70	.61	.51	.41	.31	.21	.12	4.1	8.2	2.3	6.4	70.5
44	.89	.79	.68	.58	.47	.37	.26	.16	1.05	3.7	7.4	21.0	4.7	68.3
54 45	17.89	35.77	53.66	71.55	89.43	107.32	125.21	143.10	160.99	1073.2	2146.5	3219.7	4292.9	5366.1
46	.88	.76	.64	.52	.40	.28	.16	3.04	.92	2.8	5.6	8.4	91.1	3.9
47	.87	.74	.62	.49	.36	.23	.11	2.98	.85	2.3	4.7	7.0	89.4	61.7
48	.86	.73	.59	.46	.32	.19	.05	.92	.78	1.9	3.8	5.7	7.6	59.5
49	.86	.72	.57	.43	.29	.15	5.00	.86	.72	1.5	2.9	4.4	5.9	7.3
54 50	17.85	35.70	53.55	71.40	89.25	107.10	124.95	142.80	160.65	1071.0	2142.0	3213.1	4284.1	5355.1
51	.84	.69	.53	.37	.21	.06	.90	.74	.58	0.6	1.1	1.7	2.3	2.9
52	.84	.67	.51	.34	.18	7.01	.85	.69	.52	70.1	40.3	10.4	80.6	50.7
53	.83	.66	.48	.31	.14	6.97	.80	.63	.45	69.7	39.4	09.1	78.8	48.5
54	.82	.64	.46	.28	.10	.93	.75	.57	.39	9.3	8.5	7.8	7.0	6.3
54 55	17.81	35.63	53.44	71.25	89.07	106.88	124.69	142.51	160.32	1068.8	2137.6	3206.4	4275.3	5344.1
56	.81	.61	.42	.22	9.03	.84	.64	.45	.25	8.4	6.7	5.1	3.5	41.9
57	.80	.60	.40	.19	8.99	.79	.59	.39	.19	7.9	5.8	3.8	1.7	39.7
58	.79	.58	.37	.17	.95	.75	.54	.33	.12	7.5	5.0	2.5	70.0	7.4
59	.78	.57	.35	.14	.92	.70	.49	.27	60.06	7.0	4.1	201.1	68.2	5.2
54 60	17.78	35.55	53.33	71.11	88.88	106.66	124.44	142.21	159.99	1066.6	2133.2	3199.8	4266.4	5333.0

Lat.		Latitude 54° to 55°—Meridional arcs.						Latitude 54°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
54	00	30.918			1855.10						
	1	8	1	30.92	.11	1	1 855.1	0	1	1 093.0	0.1
	2	9	2	61.84	.11	2	3 710.2		2	2 185.9	0.5
	3	9	3	92.76	.12	3	5 565.3		3	3 278.9	1.2
	4	9	4	123.68	.12	4	7 420.4		4	4 371.9	2.1
54	05	30.919	5	154.60	1855.13	5	9 275.6	0	5	5 464.8	3.2
	6	9	6	185.53	.13	6	11 130.7		6	6 557.8	4.6
	7	9	7	216.45	.14	7	12 985.8		7	7 650.8	6.3
	8	9	8	247.37	.14	8	14 841.0		8	8 743.7	8.2
	9	9	9	278.29	.15	9	16 696.1		9	9 836.7	10.4
54	10	30.919	10	309.21	1855.15	10	18 551.2	0	10	10 929.7	12.9
	11	9	1	340.13	.16	1	20 406.4		15	16 394.5	28.9
	12	9	2	371.05	.16	2	22 261.6		20	21 859.3	51.4
	13	19	3	401.97	.17	3	24 116.7		25	27 324.0	80.4
	14	20	4	432.89	.17	4	25 971.9		30	32 788.8	115.7
54	15	30.920	15	463.81	1855.18	15	27 827.1	0	35	38 253.4	157.5
	16	0	6	494.74	.18	6	29 682.3		40	43 718.0	205.8
	17	0	7	525.66	.19	7	31 537.4		45	49 182.6	260.4
	18	0	8	556.58	.19	8	33 392.6		50	54 647.1	321.5
	19	0	9	587.50	.20	9	35 247.8		55	60 111.5	389.0
54	20	30.920	20	618.42	1855.21	20	37 103.0	1	00	65 575.9	463.0
	21	0	1	649.34	.21	1	38 958.2		05	71 040.1	543.4
	22	0	2	680.26	.22	2	40 813.5		10	76 504.3	630.2
	23	0	3	711.18	.22	3	42 668.7		15	81 968.3	723.4
	24	0	4	742.10	.23	4	44 523.9		20	87 432.3	823.1
54	25	30.921	25	773.02	1855.23	25	46 379.1	1	25	92 896.1	929.1
	26	1	6	803.94	.24	6	48 234.4		30	98 359.8	1 041.7
	27	1	7	834.87	.24	7	50 089.6		35	103 823.3	1 160.6
	28	1	8	865.79	.25	8	51 944.8		40	109 286.7	1 286.0
	29	1	9	896.71	.25	9	53 800.1		45	114 750.0	1 417.8
54	30	30.921	30	927.63	1855.26	30	55 655.3	1	50	120 213.1	1 556.0
	31	1	1	958.55	.26	1	57 510.6		55	125 676.0	1 700.7
	32	1	2	989.47	.27	2	59 365.9	2	00	131 139	1 852
	33	1	3	1 020.39	.27	3	61 221.2	3	00	196 675	4 166
	34	1	4	1 051.31	.28	4	63 076.4	4	00	262 173	7 406
54	35	30.921	35	1 082.23	1855.28	35	64 931.7	5	00	327 618	11 570
	36	1	6	1 113.15	.29	6	66 787.0	6	00	392 998	16 657
	37	2	7	1 144.08	.29	7	68 642.3	7	00	458 300	22 668
	38	2	8	1 175.00	.30	8	70 497.6	8	00	523 510	29 599
	39	2	9	1 205.92	.30	9	72 352.9	9	00	588 616	37 451
54	40	30.922	40	1 236.84	1855.31	40	74 208.2	10	00	653 604	46 221
	41	2	1	1 267.76	.31	1	76 063.5	11	00	718 462	55 908
	42	2	2	1 298.68	.32	2	77 918.8	12	00	783 177	66 510
	43	2	3	1 329.60	.32	3	79 774.1	13	00	847 736	78 024
	44	2	4	1 360.52	.33	4	81 629.5	14	00	912 125	90 449
54	45	30.922	45	1 391.44	1855.34	45	83 484.8	15	00	976 333	103 782
	46	2	6	1 422.36	.34	6	85 340.1	16	00	1 040 347	118 020
	47	2	7	1 453.28	.35	7	87 195.5	17	00	1 104 152	133 161
	48	3	8	1 484.21	.35	8	89 050.8	18	00	1 167 738	149 200
	49	3	9	1 515.13	.36	9	90 906.2	19	00	1 231 091	166 136
54	50	30.923	50	1 546.05	1855.36	50	92 761.5	20	00	1 294 198	183 965
	51	3	1	1 576.97	.37	1	94 616.9	21	00	1 357 048	202 683
	52	3	2	1 607.89	.37	2	96 472.3	22	00	1 419 627	222 287
	53	3	3	1 638.81	.38	3	98 327.6	23	00	1 481 922	242 772
	54	3	4	1 669.73	.38	4	100 183.0	24	00	1 543 923	264 135
54	55	30.923	55	1 700.65	1855.39	55	102 038.4	25	00	1 605 615	286 371
	56	3	6	1 731.57	.39	6	103 893.8	26	00	1 666 988	309 476
	57	3	7	1 762.49	.40	7	105 749.2	27	00	1 728 028	333 445
	58	3	8	1 793.42	.40	8	107 604.6	28	00	1 788 723	358 274
	59	3	9	1 824.34	.41	9	109 460.0	29	00	1 849 062	383 957
54	60	30.924	60	1 855.26	1855.41	60	111 315.4	30	00	1 909 033	410 490

Latitude 55° to 56°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
55 00	17.78	35.55	53.33	71.11	88.88	106.66	124.44	142.21	159.99	1066.6	2133.2	3199.8	4266.4	5333.0
1	.77	.54	.31	.08	.84	.62	.39	.16	.92	6.2	2.3	8.5	4.7	30.8
2	.76	.52	.29	.05	.81	.57	.34	.10	.86	5.7	1.4	7.2	2.9	28.6
3	.75	.51	.26	1.02	.77	.53	.28	2.04	.79	5.3	30.6	5.8	61.1	6.4
4	.75	.49	.24	0.99	.74	.48	.23	1.98	.73	4.8	29.7	4.5	59.3	4.2
55 05	17.74	35.48	53.22	70.96	88.70	106.44	124.18	141.92	159.66	1064.4	2128.8	3193.2	4257.6	5322.0
6	.73	.47	.20	.93	.66	.40	.13	.86	.59	4.0	7.9	1.9	5.8	19.8
7	.72	.45	.18	.90	.63	.35	.08	.80	.53	3.5	7.0	90.5	4.0	7.5
8	.72	.44	.15	.87	.59	.31	4.02	.74	.46	3.1	6.2	89.2	2.3	5.3
9	.71	.42	.13	.84	.56	.26	3.97	.68	.40	2.6	5.3	7.9	50.5	3.1
55 10	17.70	35.41	53.11	70.81	88.52	106.22	123.92	141.62	159.33	1062.2	2124.4	3186.5	4248.7	5310.9
11	.70	.39	.09	.78	.48	.17	.87	.56	.26	1.7	3.5	5.2	6.9	08.7
12	.69	.38	.07	.75	.45	.13	.82	.51	.20	1.3	2.6	3.9	5.2	6.5
13	.68	.36	.04	.72	.41	.08	.76	.45	.13	0.8	1.7	2.5	3.4	4.2
14	.67	.35	.02	.69	.37	.04	.71	.39	.06	0.4	20.8	81.2	1.6	302.0
55 15	17.67	35.33	53.00	70.66	88.33	106.00	123.66	141.33	159.00	1060.0	2119.9	3179.9	4239.8	5299.8
16	.66	.32	2.98	.63	.30	5.95	.61	.27	8.93	59.5	9.0	8.6	8.1	7.6
17	.65	.30	.95	.60	.26	.91	.56	.21	.86	9.1	8.1	7.2	6.3	5.4
18	.64	.29	.93	.58	.22	.86	.50	.15	.79	8.6	7.3	5.9	4.5	3.2
19	.64	.27	.91	.55	.19	.82	.45	.09	.73	8.2	6.4	4.6	2.8	90.9
55 20	17.63	35.26	52.89	70.52	88.15	105.77	123.40	141.03	158.66	1057.7	2115.5	3173.2	4231.0	5288.7
21	.62	.24	.87	.49	.11	.73	.35	0.97	.59	7.3	4.6	1.9	29.2	6.5
22	.61	.23	.84	.46	.08	.69	.30	.91	.53	6.9	3.7	70.6	7.4	4.3
23	.61	.21	.82	.43	.04	.64	.25	.85	.46	6.4	2.8	69.2	5.6	82.1
24	.60	.20	.80	.40	8.00	.60	.20	.80	.40	6.0	1.9	7.9	3.9	79.8
55 25	17.59	35.18	52.78	70.37	87.97	105.55	123.14	140.74	158.33	1055.5	2111.0	3166.6	4222.1	5277.6
26	.58	.17	.75	.34	.93	.51	.09	.68	.26	5.1	10.1	5.2	20.3	5.4
27	.58	.15	.73	.31	.89	.46	3.04	.62	.20	4.6	09.2	3.9	18.5	3.2
28	.57	.14	.71	.28	.85	.42	2.99	.56	.13	4.2	8.4	2.6	6.8	70.9
29	.56	.12	.69	.25	.82	.37	.94	.50	.06	3.7	7.5	61.2	5.0	68.7
55 30	17.56	35.11	52.67	70.22	87.78	105.33	122.89	140.44	158.00	1053.3	2106.6	3159.9	4213.2	5266.5
31	.55	.10	.64	.19	.74	.29	.84	.38	7.93	2.9	5.7	8.6	11.4	4.3
32	.54	.08	.62	.16	.70	.24	.79	.32	.86	2.4	4.8	7.2	09.6	62.1
33	.54	.07	.60	.13	.67	.20	.73	.26	.80	2.0	3.9	5.9	7.9	59.8
34	.53	.05	.58	.10	.63	.15	.68	.20	.73	1.5	3.0	4.6	6.1	7.6
55 35	17.52	35.04	52.55	70.07	87.59	105.11	122.63	140.14	157.66	1051.1	2102.1	3153.2	4204.3	5255.4
36	.51	.02	.53	.04	.55	.06	.58	.08	.60	0.6	1.2	1.9	2.5	3.1
37	.50	5.01	.51	70.01	.51	5.02	.53	40.02	.53	50.2	100.3	50.6	200.7	50.9
38	.50	4.99	.49	69.98	.48	4.97	.47	39.97	.46	49.7	099.5	49.2	199.0	48.7
39	.49	.98	.46	.95	.44	.93	.42	.91	.40	9.3	8.6	7.9	7.2	6.5
55 40	17.48	34.96	52.44	69.92	87.40	104.89	122.37	139.85	157.33	1048.9	2097.7	3146.6	4195.4	5244.3
41	.47	.95	.42	.89	.36	.84	.32	.79	.26	8.4	6.8	5.2	3.6	42.0
42	.47	.93	.40	.86	.33	.80	.27	.73	.20	8.0	5.9	3.9	1.8	39.8
43	.46	.92	.38	.83	.29	.75	.21	.67	.13	7.5	5.0	2.5	90.0	7.6
44	.45	.90	.35	.80	.25	.71	.16	.61	.06	7.1	4.1	41.2	88.3	5.3
55 45	17.44	34.89	52.33	69.77	87.21	104.66	122.11	139.55	157.00	1046.6	2093.2	3139.9	4186.5	5233.1
46	.44	.87	.31	.74	.18	.62	.06	.49	6.93	6.2	2.3	8.5	4.7	30.9
47	.43	.86	.29	.71	.14	.57	2.01	.43	.86	5.7	1.4	7.2	2.9	28.6
48	.42	.84	.26	.69	.10	.53	1.95	.37	.79	5.3	90.6	5.8	81.1	6.4
49	.41	.83	.24	.66	.07	.48	.90	.31	.73	4.8	89.7	4.5	79.3	4.2
55 50	17.41	34.81	52.22	69.63	87.03	104.44	121.85	139.25	156.66	1044.4	2088.8	3133.2	4177.6	5221.9
51	.40	.80	.20	.60	6.99	.39	.80	.19	.59	3.9	7.9	1.8	5.8	19.7
52	.39	.78	.18	.57	.96	.35	.74	.13	.53	3.5	7.0	30.5	4.0	7.5
53	.38	.77	.15	.54	.92	.30	.69	.07	.46	3.0	6.1	29.1	2.2	5.2
54	.38	.75	.13	.51	.88	.26	.64	9.01	.39	2.6	5.2	7.8	70.4	3.0
55 55	17.37	34.74	52.11	69.48	86.85	104.22	121.58	138.95	156.33	1042.2	2084.3	3126.5	4168.6	5210.8
56	.36	.72	.09	.45	.81	.17	.53	.89	.26	1.7	3.4	5.1	6.8	08.5
57	.35	.71	.06	.42	.77	.13	.48	.83	.19	1.3	2.5	3.8	5.0	6.3
58	.35	.69	.04	.39	.73	.08	.43	.77	.12	0.8	1.6	2.4	3.2	4.1
59	.34	.68	.02	.36	.70	4.04	.37	.72	6.06	40.4	80.7	21.1	61.5	201.8
55 60	17.33	34.66	52.00	69.33	86.66	103.99	121.32	138.66	155.99	1039.9	2079.8	3119.8	4159.7	5199.6

Lat.		Latitude 55° to 56°—Meridional arcs.						Latitude 55°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
55	00	30.924			1855.41						
	1	4	1	30.93	.42	1	1 855.4	0	1	1 066.6	0.1
	2	4	2	61.85	.42	2	3 710.8		2	2 133.2	0.5
	3	4	3	92.78	.43	3	5 566.3		3	3 199.8	1.1
	4	4	4	123.70	.43	4	7 421.7		4	4 266.4	2.0
55	05	30.924	5	154.63	1855.44	5	9 277.1	0	5	5 333.0	3.2
	6	4	6	185.56	.44	6	11 132.6		6	6 399.6	4.6
	7	4	7	216.48	.45	7	12 988.0		7	7 466.2	6.2
	8	4	8	247.41	.45	8	14 843.5		8	8 532.8	8.1
	9	4	9	278.34	.46	9	16 698.9		9	9 599.4	10.3
55	10	30.924	10	309.26	1855.46	10	18 554.4	0	10	10 666.1	12.7
	11	4	1	340.19	.47	1	20 409.9		15	15 999.1	28.6
	12	5	2	371.11	.47	2	22 265.3		20	21 332.1	50.8
	13	5	3	402.04	.48	3	24 120.8		25	26 665.0	79.4
	14	5	4	432.97	.49	4	25 976.3		30	31 997.9	114.4
55	15	30.925	15	463.89	1855.49	15	27 831.8	0	35	37 330.8	155.7
	16	5	6	494.82	.50	6	29 687.3		40	42 663.6	203.3
	17	5	7	525.74	.50	7	31 542.8		45	47 996.4	257.3
	18	5	8	556.67	.51	8	33 398.3		50	53 329.1	317.7
	19	5	9	587.60	.51	9	35 253.8		55	58 661.7	384.4
55	20	30.925	20	618.52	1855.52	20	37 109.3	1	00	63 994.2	457.5
	21	5	1	649.45	.52	1	38 964.8		05	69 326.7	536.9
	22	5	2	680.37	.53	2	40 820.4		10	74 659.0	622.7
	23	6	3	711.30	.53	3	42 675.9		15	79 991.3	714.8
	24	6	4	742.23	.54	4	44 531.4		20	85 323.4	813.3
55	25	30.926	25	773.15	1855.54	25	46 387.0	1	25	90 655.4	918.1
	26	6	6	804.08	.55	6	48 242.5		30	95 987.3	1 029.3
	27	6	7	835.01	.55	7	50 098.1		35	101 319.0	1 146.8
	28	6	8	865.93	.56	8	51 953.6		40	106 650.6	1 270.7
	29	6	9	896.86	.56	9	53 809.2		45	111 982.1	1 400.9
55	30	30.926	30	927.78	1855.57	30	55 664.7	1	50	117 313.3	1 537.5
	31	6	1	958.71	.57	1	57 520.3		55	122 644.5	1 680.5
	32	6	2	989.64	.58	2	59 375.9	2	00	127 975	1 830
	33	6	3	1 020.56	.58	3	61 231.4	3	00	191 930	4 117
	34	6	4	1 051.49	.59	4	63 087.0	4	00	255 846	7 318
55	35	30.927	35	1 082.41	1855.59	35	64 942.6	5	00	319 710	11 432
	36	7	6	1 113.34	.60	6	66 798.2	6	00	383 508	16 459
	37	7	7	1 144.27	.60	7	68 653.8	7	00	447 228	22 398
	38	7	8	1 175.19	.61	8	70 509.4	8	00	510 856	29 246
	39	7	9	1 206.12	.61	9	72 365.0	9	00	574 380	37 004
55	40	30.927	40	1 237.04	1855.62	40	74 220.7	10	00	637 786	45 670
	41	7	1	1 267.97	.62	1	76 076.3	11	00	701 062	55 240
	42	7	2	1 298.90	.63	2	77 931.9	12	00	764 195	65 715
	43	7	3	1 329.82	.63	3	79 787.6	13	00	827 172	77 091
	44	7	4	1 360.75	.64	4	81 643.2	14	00	889 980	89 366
55	45	30.927	45	1 391.68	1855.64	45	83 498.8	15	00	952 605	102 538
	46	7	6	1 422.60	.65	6	85 354.5	16	00	1 015 036	116 604
	47	8	7	1 453.53	.65	7	87 210.1	17	00	1 077 260	131 561
	48	8	8	1 484.45	.66	8	89 065.8	18	00	1 139 263	147 406
	49	8	9	1 515.38	.66	9	90 921.5	19	00	1 201 033	164 135
55	50	30.928	50	1 546.31	1855.67	50	92 777.1	20	00	1 262 558	181 747
	51	8	1	1 577.23	.68	1	94 632.8	21	00	1 323 825	200 236
	52	8	2	1 608.16	.68	2	96 488.4	22	00	1 384 821	219 599
	53	8	3	1 639.08	.69	3	98 344.1	23	00	1 445 535	239 852
	54	8	4	1 670.01	.69	4	100 199.8	24	00	1 505 952	260 931
55	55	30.928	55	1 700.94	1855.70	55	102 055.5	25	00	1 566 063	282 891
	56	8	6	1 731.86	.70	6	103 911.2	26	00	1 625 853	305 709
	57	8	7	1 762.79	.71	7	105 766.9	27	00	1 685 310	329 379
	58	9	8	1 793.72	.71	8	107 622.6	28	00	1 744 423	353 896
	59	9	9	1 824.64	.72	9	109 478.3	29	00	1 803 179	379 257
55	60	30.929	60	1 855.57	1855.72	60	111 334.0	30	00	1 861 567	405 454

Latitude 56° to 57°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
56 00	17.33	34.66	52.00	69.33	86.66	103.99	121.32	138.66	155.99	1039.9	2079.8	3119.8	4159.7	5199.6
1	.32	.65	1.97	.30	.62	.95	.27	.60	.92	9.5	8.9	8.4	7.9	7.3
2	.32	.63	.95	.27	.59	.90	.22	.54	.86	9.0	8.0	7.1	6.1	5.1
3	.31	.62	.93	.24	.55	.86	.16	.48	.79	8.6	7.2	5.7	4.3	2.9
4	.30	.60	.91	.21	.51	.81	.11	.42	.72	8.1	6.3	4.4	2.5	90.6
56 05	17.29	34.59	51.88	69.18	86.48	103.77	121.06	138.36	155.65	1037.7	2075.4	3113.0	4150.7	5188.4
6	.29	.57	.86	.15	.44	.72	1.01	.30	.59	7.2	4.5	1.7	48.9	6.1
7	.28	.56	.84	.12	.40	.68	0.96	.24	.52	6.8	3.6	10.3	7.1	3.9
8	.27	.54	.82	.09	.36	.63	.90	.18	.45	6.3	2.7	09.0	5.3	81.7
9	.26	.53	.79	.06	.33	.59	.85	.12	.38	5.9	1.8	7.7	3.5	79.4
56 10	17.26	34.51	51.77	69.03	86.29	103.54	120.80	138.06	155.32	1035.4	2070.9	3106.3	4141.7	5177.2
11	.25	.50	.75	9.00	.25	.50	.75	8.00	.25	5.0	70.0	5.0	40.0	4.9
12	.24	.48	.73	8.97	.21	.45	.70	7.94	.18	4.5	69.1	3.6	38.2	2.7
13	.23	.47	.70	.94	.18	.41	.64	.88	.11	4.1	8.2	2.3	6.4	70.4
14	.23	.45	.68	.91	.14	.36	.59	.82	5.05	3.6	7.3	100.9	4.6	68.2
56 15	17.22	34.44	51.66	68.88	86.10	103.32	120.54	137.76	154.98	1033.2	2066.4	3099.6	4132.8	5166.0
16	.21	.43	.64	.85	.06	.27	.49	.70	.91	2.7	5.5	8.2	31.0	3.7
17	.20	.41	.62	.82	6.02	.23	.44	.64	.84	2.3	4.6	6.9	29.2	61.5
18	.20	.40	.59	.79	5.99	.18	.38	.58	.78	1.8	3.7	5.5	7.4	59.2
19	.19	.38	.57	.76	.95	.14	.33	.52	.71	1.4	2.8	4.2	5.6	7.0
56 20	17.18	34.37	51.55	68.73	85.91	103.09	120.28	137.46	154.64	1030.9	2061.9	3092.8	4123.8	5154.7
21	.17	.35	.53	.70	.87	.05	.23	.40	.57	0.5	1.0	1.5	2.0	2.5
22	.17	.34	.50	.67	.84	3.00	.17	.34	.51	30.0	60.1	90.1	20.2	50.2
23	.16	.32	.48	.64	.80	2.96	.12	.28	.44	29.6	59.2	88.8	18.4	48.0
24	.15	.31	.46	.61	.76	.91	.07	.22	.37	9.1	8.3	7.4	6.6	5.7
56 25	17.14	34.29	51.43	68.58	85.73	102.87	120.01	137.16	154.31	1028.7	2057.4	3086.1	4114.8	5143.5
26	.14	.28	.41	.55	.69	.82	19.96	.10	.24	8.2	6.5	4.7	3.0	41.2
27	.13	.26	.39	.52	.65	.78	.91	7.04	.17	7.8	5.6	3.4	11.2	39.0
28	.12	.25	.37	.49	.61	.74	.86	6.98	.10	7.4	4.7	2.1	09.4	6.8
29	.12	.23	.34	.46	.58	.69	.80	.92	4.04	6.9	3.8	80.7	7.6	4.5
56 30	17.11	34.22	51.32	68.43	85.54	102.65	119.75	136.86	153.97	1026.5	2052.9	3079.4	4105.8	5132.3
31	.10	.20	.30	.40	.50	.60	.70	.80	.90	6.0	2.0	8.0	4.0	30.0
32	.09	.19	.28	.37	.46	.55	.65	.74	.83	5.5	1.1	6.6	2.2	27.7
33	.09	.17	.25	.34	.43	.51	.59	.68	.77	5.1	50.2	5.3	100.4	5.5
34	.08	.16	.23	.31	.39	.46	.54	.62	.70	4.6	49.3	3.9	098.6	3.2
56 35	17.07	34.14	51.21	68.28	85.35	102.42	119.49	136.56	153.63	1024.2	2048.4	3072.6	4096.8	5121.0
36	.06	.12	.19	.25	.31	.37	.44	.50	.56	3.7	7.5	71.2	5.0	18.7
37	.05	.11	.17	.22	.27	.33	.39	.44	.49	3.3	6.6	69.9	3.2	6.5
38	.05	.09	.14	.19	.24	.28	.33	.38	.43	2.8	5.7	8.5	91.4	4.2
39	.04	.08	.12	.16	.20	.24	.28	.32	.36	2.4	4.8	7.2	89.6	12.0
56 40	17.03	34.06	51.10	68.13	85.16	102.19	119.23	136.26	153.29	1021.9	2043.9	3065.8	4087.8	5109.7
41	.02	.05	.08	.10	.12	.15	.18	.20	.22	1.5	3.0	4.5	6.0	7.5
42	.02	.03	.05	.07	.09	.10	.12	.14	.15	1.0	2.1	3.1	4.2	5.2
43	.01	.02	.03	.04	.05	.06	.07	.08	.09	0.6	1.2	1.8	2.4	2.9
44	.00	4.00	1.01	8.01	5.01	2.01	9.02	6.02	3.02	20.1	40.3	60.4	80.6	100.7
56 45	17.00	33.99	50.98	67.98	84.98	101.97	118.96	135.96	152.95	1019.7	2039.4	3059.1	4078.7	5098.4
46	6.99	.97	.96	.95	.94	.92	.91	.90	.88	9.2	8.5	7.7	6.9	6.2
47	.98	.96	.94	.92	.90	.88	.86	.84	.82	8.8	7.6	6.4	5.1	3.9
48	.97	.94	.92	.89	.86	.83	.81	.78	.75	8.3	6.7	5.0	3.3	91.7
49	.96	.93	.89	.86	.83	.79	.75	.72	.68	7.9	5.8	3.6	71.5	89.4
56 50	16.96	33.91	50.87	67.83	84.79	101.74	118.70	135.66	152.61	1017.4	2034.9	3052.3	4069.7	5087.2
51	.95	.90	.85	.80	.75	.70	.65	.60	.54	7.0	4.0	50.9	7.9	4.9
52	.94	.88	.83	.77	.71	.65	.59	.54	.48	6.5	3.1	49.6	6.1	2.6
53	.93	.87	.80	.74	.68	.61	.54	.48	.41	6.1	2.1	8.2	4.3	80.4
54	.93	.85	.78	.71	.64	.56	.49	.42	.34	5.6	1.2	6.9	2.5	78.1
56 55	16.92	33.84	50.76	67.68	84.60	101.52	118.43	135.36	152.27	1015.2	2030.3	3045.5	4060.7	5075.8
56	.91	.82	.74	.65	.56	.47	.38	.30	.21	4.7	29.4	4.1	58.9	3.6
57	.90	.81	.71	.62	.52	.43	.33	.24	.14	4.3	8.5	2.8	7.1	71.3
58	.90	.79	.69	.59	.49	.38	.28	.17	.07	3.8	7.6	1.4	5.2	69.1
59	.89	.78	.67	.56	.45	.34	.22	.11	2.01	3.4	6.7	40.1	3.4	6.8
56 60	16.88	33.76	50.65	67.53	84.41	101.29	118.17	135.05	151.94	1012.9	2025.8	3038.7	4051.6	5064.5

Lat.		Latitude 56° to 57°—Meridional arcs.						Latitude 56°—Co-ordinates of curvature.			
		Value of 1′	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
56	00	30.929			1855.72						
	1	9	1	30.93	.73	1	1 855.7	0	1	1 039.9	0.1
	2	9	2	61.86	.73	2	3 711.5		2	2 079.8	0.5
	3	9	3	92.79	.74	3	5 567.2		3	3 119.8	1.1
	4	9	4	123.72	.74	4	7 422.9		4	4 159.7	2.0
56	05	30.929	5	154.66	1855.75	5	9 278.7	0	5	5 199.6	3.1
	6	9	6	185.59	.75	6	11 134.4		6	6 239.5	4.5
	7	9	7	216.52	.76	7	12 990.2		7	7 279.4	6.1
	8	9	8	247.45	.76	8	14 845.9		8	8 319.3	8.0
	09	29	9	278.38	.77	9	16 701.7		9	9 359.2	10.2
56	10	30.930	10	309.31	1855.77	10	18 557.5	0	10	10 399.2	12.5
	11	0	1	340.24	.78	1	20 413.2		15	15 598.7	28.2
	12	0	2	371.17	.78	2	22 269.0		20	20 798.3	50.2
	13	0	3	402.11	.79	3	24 124.8		25	25 997.8	78.4
	14	0	4	433.04	.79	4	25 980.6		30	31 197.3	112.9
56	15	30.930	15	463.97	1855.80	15	27 836.4	0	35	36 396.7	153.6
	16	0	6	494.90	.80	6	29 692.2		40	41 596.0	200.6
	17	0	7	525.83	.81	7	31 548.0		45	46 795.4	253.9
	18	0	8	556.76	.81	8	33 403.8		50	51 994.6	313.5
	19	0	9	587.69	.82	9	35 259.6		55	57 193.8	379.3
56	20	30.930	20	618.62	1855.82	20	37 115.4	1	00	62 392.9	451.4
	21	0	1	649.56	.83	1	38 971.3		05	67 591.9	529.8
	22	1	2	680.49	.83	2	40 827.1		10	72 790.8	614.4
	23	1	3	711.42	.84	3	42 682.9		15	77 989.6	705.3
	24	1	4	742.35	.84	4	44 538.8		20	83 188.2	802.5
56	25	30.931	25	773.28	1855.85	25	46 394.6	1	25	88 386.8	905.9
	26	1	6	804.21	.85	6	48 250.5		30	93 585.2	1 015.6
	27	1	7	835.14	.86	7	50 106.3		35	98 783.5	1 131.6
	28	1	8	866.07	.86	8	51 962.2		40	103 981.7	1 253.8
	29	1	9	897.01	.87	9	53 818.0		45	109 179.7	1 382.4
56	30	30.931	30	927.94	1855.87	30	55 673.9	1	50	114 377.5	1 517.1
	31	1	1	958.87	.88	1	57 529.8		55	119 575.2	1 658.2
	32	1	2	989.80	.88	2	59 385.7	2	00	124 773	1 806
	33	1	3	1 020.73	.89	3	61 241.6	3	00	187 126	4 062
	34	2	4	1 051.66	.89	4	63 097.5	4	00	249 441	7 221
56	35	30.932	35	1 082.59	1855.90	35	64 953.4	5	00	311 703	11 280
	36	2	6	1 113.52	.90	6	66 809.3	6	00	373 900	16 241
	37	2	7	1 144.46	.91	7	68 665.2	7	00	436 019	22 100
	38	2	8	1 175.39	.91	8	70 521.1	8	00	498 047	28 858
	39	2	9	1 206.32	.92	9	72 377.0	9	00	559 970	36 512
56	40	30.932	40	1 237.25	1855.92	40	74 232.9	10	00	621 776	45 062
	41	2	1	1 268.18	.93	1	76 088.8	11	00	683 451	54 506
	42	2	2	1 299.11	.93	2	77 944.8	12	00	744 984	64 840
	43	2	3	1 330.04	.94	3	79 800.7	13	00	806 361	76 064
	44	2	4	1 360.97	.94	4	81 656.7	14	00	867 569	88 174
56	45	30.932	45	1 391.91	1855.95	45	83 512.6	15	00	928 595	101 169
	46	3	6	1 422.84	.95	6	85 368.6	16	00	989 427	115 046
	47	3	7	1 453.77	.96	7	87 224.5	17	00	1 050 051	129 801
	48	3	8	1 484.70	.96	8	89 080.5	18	00	1 110 456	145 432
	49	3	9	1 515.63	.97	9	90 936.4	19	00	1 170 629	161 935
56	50	30.933	50	1 546.56	1855.97	50	92 792.4	20	00	1 230 556	179 308
	51	3	1	1 577.49	.98	1	94 648.4	21	00	1 290 226	197 545
	52	3	2	1 608.42	.98	2	96 504.4	22	00	1 349 625	216 644
	53	3	3	1 639.36	5.99	3	98 360.4	23	00	1 408 742	236 600
	54	3	4	1 670.29	6.00	4	100 216.3	24	00	1 467 564	257 410
56	55	30.933	55	1 701.22	1856.00	55	102 072.3	25	00	1 526 079	279 069
	56	3	6	1 732.15	.01	6	103 928.3	26	00	1 584 275	301 572
	57	4	7	1 763.08	.01	7	105 784.4	27	00	1 642 138	324 914
	58	4	8	1 794.01	.02	8	107 640.4	28	00	1 699 658	349 092
	59	4	9	1 824.94	.02	9	109 496.4	29	00	1 756 822	374 099
56	60	30.934	60	1 855.87	1856.03	60	111 352.4	30	00	1 813 618	399 930

Latitude 57° to 58°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
57 00	16.88	33.76	50.65	67.53	84.41	101.29	118.17	135.05	151.94	1012.9	2025.8	3038.7	4051.6	5064.5
1	.87	.75	.62	50	.37	.25	.12	4.99	.87	2.5	4.9	7.4	49.8	2.3
2	.87	.73	.60	.47	.33	.20	.06	.93	.80	2.0	4.0	6.0	8.0	60.0
3	.86	.72	.58	.44	.30	.15	8.01	.87	.73	1.5	3.1	4.6	6.2	57.7
4	.85	.70	.56	.41	.26	.11	7.96	.81	.67	1.1	2.2	3.3	4.4	5.5
57 05	16.84	33.69	50.53	67.38	84.22	101.06	117.90	134.75	151.60	1010.6	2021.3	3031.9	4042.6	5053.2
6	.84	.67	.51	.35	.18	1.02	.85	.69	.53	10.2	20.4	30.6	40.7	50.9
7	.83	.66	.49	.32	.14	0.97	.80	.63	.46	09.7	19.5	29.2	38.9	48.7
8	.82	.64	.46	.29	.11	.93	.75	.57	.39	9.3	8.6	7.8	7.1	6.4
9	.81	.63	.44	.26	.07	.88	.69	.51	.32	8.8	7.7	6.5	5.3	4.1
57 10	16.81	33.61	50.42	67.23	84.03	100.84	117.64	134.45	151.26	1008.4	2016.8	3025.1	4033.5	5041.9
11	.80	.60	.40	.20	3.99	.79	.59	.39	.19	7.9	5.9	3.8	31.7	39.6
12	.79	.58	.37	.17	.95	.75	.53	.33	.12	7.5	5.0	2.4	29.9	7.3
13	.78	.57	.35	.13	.92	.70	.48	.27	1.05	7.0	4.0	21.0	8.0	5.1
14	.78	.55	.33	.10	.88	.66	.43	.21	0.99	6.6	3.1	19.7	6.2	2.8
57 15	16.77	33.54	50.30	67.07	83.84	100.61	117.37	134.15	150.92	1006.1	2012.2	3018.3	4024.4	5030.5
16	.76	.52	.28	.04	.80	.56	.32	.09	.85	5.6	1.3	6.9	2.6	28.2
17	.75	.51	.26	7.01	.76	.52	.27	4.03	.78	5.2	10.4	5.6	20.8	6.0
18	.75	.49	.24	6.98	.73	.47	.22	3.97	.71	4.7	09.5	4.2	19.0	3.7
19	.74	.48	.21	.95	.69	.43	.16	.90	.65	4.3	8.6	2.9	7.1	21.4
57 20	16.73	33.46	50.19	66.92	83.65	100.38	117.11	133.84	150.58	1003.8	2007.7	3011.5	4015.3	5019.2
21	.72	.45	.17	.89	.61	.34	.06	.78	.51	3.4	6.8	10.1	3.5	6.9
22	.72	.43	.15	.86	.57	.29	7.00	.72	.44	2.9	5.9	08.8	11.7	4.6
23	.71	.42	.12	.83	.54	.25	6.95	.66	.37	2.5	4.9	7.4	09.9	2.3
24	.70	.40	.10	.80	.50	.20	.90	.60	.30	2.0	4.0	6.0	8.1	10.1
57 25	16.69	33.39	50.08	66.77	83.46	100.16	116.84	133.54	150.24	1001.6	2003.1	3004.7	4006.2	5007.8
26	.68	.37	.05	.74	.42	.11	.79	.48	.17	1.1	2.2	3.3	4.4	5.5
27	.68	.35	.03	.71	.38	.06	.74	.42	.10	0.6	1.3	1.9	2.6	3.2
28	.67	.34	50.01	.68	.35	100.02	.69	.36	50.03	1000.2	2000.4	3000.6	4000.8	5001.0
29	.66	.32	49.99	.65	.31	99.97	.63	.30	49.96	999.7	1999.5	2999.2	3999.0	4998.7
57 30	16.65	33.31	49.96	66.62	83.27	99.93	116.58	133.24	149.89	999.3	1998.6	2997.9	3997.1	4996.4
31	.65	.29	.94	.59	.23	.88	.53	.18	.82	8.8	7.7	6.5	5.3	4.1
32	.64	.28	.92	.56	.19	.84	.47	.12	.75	8.4	6.8	5.1	3.5	91.9
33	.63	.26	.90	.53	.16	.79	.42	.06	.69	7.9	5.8	3.7	91.7	89.6
34	.62	.25	.87	.50	.12	.75	.37	3.00	.62	7.5	4.9	2.4	89.8	7.3
57 35	16.62	33.23	49.85	66.47	83.08	99.70	116.31	132.93	149.55	997.0	1994.0	2991.0	3988.0	4985.0
36	.61	.22	.83	.44	.04	.65	.26	.87	.48	6.5	3.1	89.6	6.2	2.7
37	.60	.20	.81	.41	3.00	.61	.21	.81	.41	6.1	2.2	8.3	4.4	80.5
38	.59	.19	.78	.38	2.97	.56	.16	.75	.35	5.6	1.3	6.9	2.5	78.2
39	.59	.17	.76	.35	.93	.52	.10	.69	.28	5.2	90.4	5.5	80.7	5.9
57 40	16.58	33.16	49.74	66.32	82.89	99.47	116.05	132.63	149.21	994.7	1989.5	2984.2	3978.9	4973.6
41	.57	.14	.71	.29	.85	.43	6.00	.57	.14	4.3	8.6	2.8	7.1	71.3
42	.56	.13	.69	.25	.81	.38	5.94	.51	.07	3.8	7.6	1.4	5.3	69.1
43	.56	.11	.67	.22	.78	.34	.89	.45	9.01	3.4	6.7	80.1	3.4	6.8
44	.55	.10	.65	.19	.74	.29	.84	.39	8.94	2.9	5.8	78.7	71.6	4.5
57 45	16.54	33.08	49.62	66.16	82.70	99.24	115.78	132.33	148.87	992.4	1984.9	2977.3	3969.8	4962.2
46	.53	.07	.60	.13	.66	.20	.73	.26	.80	2.0	4.0	6.0	7.9	59.9
47	.53	.05	.58	.10	.62	.15	.68	.20	.73	1.5	3.1	4.6	6.1	7.6
48	.52	.04	.55	.07	.59	.11	.63	.14	.66	1.1	2.1	3.2	4.3	5.4
49	.51	.02	.53	.04	.55	.06	.57	.08	.59	0.6	1.2	1.8	2.5	3.1
57 50	16.50	33.01	49.51	66.01	82.51	99.02	115.52	132.02	148.53	990.2	1980.3	2970.5	3960.6	4950.8
51	.49	2.99	.49	5.98	.47	8.97	.47	1.96	.46	89.7	79.4	69.1	58.8	48.5
52	.49	.97	.46	.95	.43	.92	.41	.90	.39	9.2	8.5	7.7	7.0	6.2
53	.48	.96	.44	.92	.40	.88	.36	.84	.32	8.8	7.5	6.4	5.1	3.9
54	.47	.94	.42	.89	.36	.83	.30	.78	.25	8.3	6.6	5.0	3.3	41.6
57 55	16.46	32.93	49.39	65.86	82.32	98.79	115.25	131.72	148.18	987.9	1975.7	2963.6	3951.5	4939.4
56	.46	.91	.37	.83	.28	.74	.20	.66	.11	7.4	4.8	2.2	49.7	7.1
57	.45	.90	.35	.80	.24	.70	.14	.59	8.04	7.0	3.9	60.9	7.8	4.8
58	.44	.88	.33	.77	.21	.65	.09	.53	7.97	6.5	3.0	59.5	6.0	2.5
59	.43	.87	.30	.74	.17	.60	5.03	.47	.90	6.0	2.1	8.1	4.2	30.2
57 60	16.43	32.85	49.28	65.71	82.13	98.56	114.98	131.41	147.84	985.6	1971.2	2956.8	3942.3	4927.9

Lat.	Latitude 57° to 58°—Meridional arcs.						Latitude 57°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
57 00	30.934			1856.03					
1	4	1	30.94	.03	1	1 856.0	0 1	1 012.9	0.1
2	4	2	61.87	.04	2	3 712.1	2	2 025.8	0.5
3	4	3	92.81	.04	3	5 568.1	3	3 038.7	1.1
4	4	4	123.75	.05	4	7 424.1	4	4 051.6	2.0
57 05	30.934	5	154.68	1856.05	5	9 280.2	0 5	5 064.5	3.1
6	4	6	185.62	.06	6	11 136.2	6	6 077.4	4.4
7	4	7	216.55	.06	7	12 992.3	7	7 090.3	6.0
8	4	8	247.49	.07	8	14 848.4	8	8 103.3	7.9
9	5	9	278.43	.07	9	16 704.4	9	9 116.2	10.0
57 10	30.935	10	309.36	1856.08	10	18 560.5	0 10	10 129.1	12.4
11	5	1	340.30	.08	1	20 416.6	15	15 193.6	27.8
12	5	2	371.24	.09	2	22 272.7	20	20 258.1	49.4
13	5	3	402.17	.09	3	24 128.7	25	25 322.5	77.2
14	5	4	433.11	.10	4	25 984.8	30	30 387.0	111.2
57 15	30.935	15	464.04	1856.10	15	27 840.9	0 35	35 451.3	151.3
16	5	6	494.98	.11	6	29 697.0	40	40 515.6	197.7
17	5	7	525.92	.11	7	31 553.1	45	45 579.9	250.2
18	5	8	556.85	.12	8	33 409.3	50	50 644.1	308.9
19	5	9	587.79	.12	9	35 265.4	55	55 708.2	373.7
57 20	30.935	20	618.73	1856.13	20	37 121.5	1 00	60 772.3	444.8
21	6	1	649.66	.13	1	38 977.6	05	65 836.2	522.0
22	6	2	680.60	.14	2	40 833.7	10	70 900.1	605.4
23	6	3	711.53	.14	3	42 689.9	15	75 963.8	695.0
24	6	4	742.47	.15	4	44 546.0	20	81 027.5	790.7
57 25	30.936	25	773.41	1856.15	25	46 402.2	1 25	86 091.0	892.6
26	6	6	804.34	.16	6	48 258.3	30	91 154.3	1 000.7
27	6	7	835.28	.16	7	50 114.5	35	96 217.6	1 115.0
28	6	8	866.22	.17	8	51 970.7	40	101 280.7	1 235.5
29	6	9	897.15	.17	9	53 826.8	45	106 343.6	1 362.1
57 30	30.936	30	928.09	1856.18	30	55 683.0	1 50	111 406.4	1 494.9
31	6	1	959.02	.18	1	57 539.2	55	116 469.1	1 633.9
32	6	2	989.96	.19	2	59 395.4	2 00	121 532	1 779
33	7	3	1 020.90	.19	3	61 251.6	3 00	182 265	4 003
34	7	4	1 051.83	.20	4	63 107.8	4 00	242 959	7 115
57 35	30.937	35	1 082.77	1856.20	35	64 964.0	5 00	303 601	11 115
36	7	6	1 113.71	.21	6	66 820.2	6 00	364 178	16 002
37	7	7	1 144.64	.21	7	68 676.4	7 00	424 677	21 776
38	7	8	1 175.58	.22	8	70 532.6	8 00	485 085	28 434
39	7	9	1 206.51	.22	9	72 388.8	9 00	545 389	35 976
57 40	30.937	40	1 237.45	1856.23	40	74 245.0	10 00	605 577	44 400
41	7	1	1 268.39	.23	1	76 101.3	11 00	665 634	53 704
42	7	2	1 299.32	.24	2	77 957.5	12 00	725 549	63 886
43	7	3	1 330.26	.24	3	79 813.7	13 00	785 308	74 944
44	7	4	1 361.20	.25	4	81 669.9	14 00	844 900	86 875
57 45	30.938	45	1 392.13	1856.25	45	83 526.2	15 00	904 310	99 677
46	8	6	1 423.07	.26	6	85 382.5	16 00	963 526	113 348
47	8	7	1 454.00	.26	7	87 238.7	17 00	1 022 536	127 884
48	8	8	1 484.94	.27	8	89 095.0	18 00	1 081 327	143 282
49	8	9	1 515.88	.27	9	90 951.2	19 00	1 139 886	159 539
57 50	30.938	50	1 546.81	1856.28	50	92 807.5	20 00	1 198 201	176 651
51	8	1	1 577.75	.28	1	94 663.8	21 00	1 256 260	194 615
52	8	2	1 608.69	.29	2	96 520.1	22 00	1 314 048	213 427
53	8	3	1 639.62	.29	3	98 376.4	23 00	1 371 556	233 082
54	8	4	1 670.56	.30	4	100 232.7	24 00	1 428 770	253 578
57 55	30.938	55	1 701.49	1856.30	55	102 089.0	25 00	1 485 678	274 908
56	8	6	1 732.43	.31	6	103 945.3	26 00	1 542 267	297 070
57	9	7	1 763.37	.31	7	105 801.6	27 00	1 598 525	320 057
58	9	8	1 794.30	.31	8	107 657.9	28 00	1 654 442	343 865
59	9	9	1 825.24	.32	9	109 514.2	29 00	1 710 004	368 489
57 60	30.939	60	1 856.18	1856.32	60	111 370.5	30 00	1 765 199	393 924

Latitude 58° to 59°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
58 00	16.43	32.85	49.28	65.71	82.13	98.56	114.98	131.41	147.84	985.6	1971.2	2956.8	3942.3	4927.9
1	.42	.84	.26	.68	.09	.51	.93	.35	.77	5.1	70.3	5.4	40.5	5.6
2	.41	.82	.23	.65	.06	.47	.87	.29	.70	4.7	69.4	4.0	38.7	3.3
3	.40	.81	.21	.61	2.02	.42	.82	.23	.63	4.2	8.4	2.6	6.8	21.0
4	.40	.79	.19	.58	1.98	.38	.77	.17	.56	3.8	7.5	51.3	5.0	18.8
58 05	16.39	32.78	49.16	65.55	81.94	98.33	114.71	131.11	147.49	983.3	1966.6	2949.9	3933.2	4916.5
6	.38	.76	.14	.52	.90	.28	.66	1.04	.42	2.8	5.7	8.5	31.3	4.2
7	.37	.75	.12	.49	.86	.24	.61	0.98	.35	2.4	4.8	7.1	29.5	11.9
8	.37	.73	.10	.46	.83	.19	.56	.92	.29	1.9	3.8	5.8	7.7	09.6
9	.36	.72	.07	.43	.79	.15	.50	.86	.22	1.5	2.9	4.4	5.8	7.3
58 10	16.35	32.70	49.05	65.40	81.75	98.10	114.45	130.80	147.15	981.0	1962.0	2943.0	3924.0	4905.0
11	.34	.68	.03	.37	.71	.05	.40	.74	.08	0.5	1.1	1.6	2.2	2.7
12	.33	.67	9.00	.34	.67	8.01	.34	.68	7.01	80.1	60.2	40.2	20.3	900.4
13	.33	.65	8.98	.31	.64	7.96	.29	.62	6.94	79.6	59.2	38.9	18.5	898.1
14	.32	.64	.96	.28	.60	.92	.23	.56	.87	9.2	8.3	7.5	6.7	5.8
58 15	16.31	32.62	48.93	65.25	81.56	97.87	114.18	130.49	146.81	978.7	1957.4	2936.1	3914.8	4893.5
16	.30	.61	.91	.22	.52	.82	.13	.43	.74	8.2	6.5	4.7	3.0	91.2
17	.30	.59	.89	.19	.48	.78	.07	.37	.67	7.8	5.6	3.4	11.1	88.9
18	.29	.58	.87	.15	.45	.73	4.02	.31	.60	7.3	4.6	2.0	09.3	6.6
19	.28	.56	.84	.12	.41	.69	3.96	.25	.53	6.9	3.7	30.6	7.5	4.3
58 20	16.27	32.55	48.82	65.09	81.37	97.64	113.91	130.19	146.46	976.4	1952.8	2929.2	3905.6	4882.0
21	.26	.53	.80	.06	.33	.59	.86	.13	.39	5.9	1.9	7.8	3.8	79.7
22	.26	.52	.77	.03	.29	.55	.80	.07	.32	5.5	1.0	6.5	2.0	7.4
23	.25	.50	.75	5.00	.25	.50	.75	30.00	.25	5.0	50.0	5.1	900.1	5.1
24	.24	.49	.73	4.97	.21	.46	.70	29.94	.18	4.6	49.1	3.7	898.3	2.8
58 25	16.24	32.47	48.70	64.94	81.18	97.41	113.64	129.88	146.12	974.1	1948.2	2922.3	3896.4	4870.5
26	.23	.45	.68	.91	.14	.36	.59	.82	6.05	3.6	7.3	20.9	4.6	68.2
27	.22	.44	.66	.88	.10	.32	.54	.76	5.98	3.2	6.4	19.6	2.8	5.9
28	.21	.42	.64	.85	.06	.27	.49	.70	.91	2.7	5.4	8.2	90.9	3.6
29	.20	.41	.61	.82	1.02	.23	.43	.64	.84	2.3	4.5	6.8	89.1	61.3
58 30	16.20	32.39	48.59	64.79	80.98	97.18	113.38	129.57	145.77	971.8	1943.6	2915.4	3887.2	4859.0
31	.19	.38	.57	.76	.94	.13	.33	.51	.70	1.3	2.7	4.0	5.4	6.7
32	.18	.36	.54	.73	.90	.09	.27	.45	.63	0.9	1.8	2.7	3.5	4.4
33	.17	.35	.52	.69	.87	.04	.22	.39	.56	0.4	40.8	11.3	81.7	52.1
34	.17	.33	.50	.66	.83	7.00	.16	.33	.49	70.0	39.9	09.9	79.9	49.8
58 35	16.16	32.32	48.47	64.63	80.79	96.95	113.11	129.27	145.43	969.5	1939.0	2908.5	3878.0	4847.5
36	.15	.30	.45	.60	.75	.90	.06	.21	.36	9.0	8.1	7.1	6.2	5.2
37	.14	.29	.43	.57	.71	.86	3.00	.14	.29	8.6	7.2	5.7	4.3	2.9
38	.14	.27	.41	.54	.68	.81	2.95	.08	.22	8.1	6.2	4.4	2.5	40.6
39	.13	.26	.38	.51	.64	.77	.89	9.02	.15	7.7	5.3	3.0	70.6	38.3
58 40	16.12	32.24	48.36	64.48	80.60	96.72	112.84	128.96	145.08	967.2	1934.4	2901.6	3868.8	4836.0
41	.11	.22	.34	.45	.56	.67	.79	.90	5.01	6.7	3.5	900.2	6.9	3.7
42	.10	.21	.31	.42	.52	.63	.73	.84	4.94	6.3	2.6	898.8	5.1	31.4
43	.10	.19	.29	.39	.49	.58	.68	.78	.87	5.8	1.6	7.4	3.3	29.1
44	.09	.18	.27	.36	.45	.54	.62	.71	.80	5.4	30.7	6.1	61.4	6.8
58 45	16.08	32.16	48.24	64.33	80.41	96.49	112.57	128.65	144.73	964.9	1929.8	2894.7	3859.6	4824.4
46	.07	.15	.22	.30	.37	.44	.52	.59	.67	4.4	8.9	3.3	7.7	22.1
47	.06	.13	.20	.27	.33	.40	.46	.53	.60	4.0	8.0	1.9	5.9	19.8
48	.06	.12	.18	.23	.30	.35	.41	.47	.53	3.5	7.0	90.5	4.0	7.5
49	.05	.10	.15	.20	.26	.30	.35	.41	.46	3.0	6.1	89.1	2.2	5.2
58 50	16.04	32.09	48.13	64.17	80.22	96.26	112.30	128.34	144.39	962.6	1925.2	2887.7	3850.3	4812.9
51	.04	.07	.11	.14	.18	.21	.25	.28	.32	2.1	4.3	6.4	48.5	10.6
52	.03	.06	.08	.11	.14	.17	.19	.22	.25	1.7	3.3	5.0	6.6	08.3
53	.02	.04	.06	.08	.10	.12	.14	.16	.18	1.2	2.4	3.6	4.8	6.0
54	.01	.02	.04	.05	.06	.07	.08	.10	.11	0.7	1.4	2.2	2.9	3.7
58 55	16.00	32.01	48.01	64.02	80.02	96.03	112.03	128.04	144.04	960.3	1920.5	2880.8	3841.1	4801.3
56	6.00	1.99	7.99	3.99	79.99	5.98	1.98	7.97	3.97	59.8	19.6	79.4	39.2	799.0
57	5.99	.98	.97	.96	.95	.93	.92	.91	.90	9.3	8.7	8.0	7.4	6.7
58	.98	.96	.94	.92	.91	.89	.87	.85	.83	8.9	7.7	6.6	5.5	4.4
59	.97	.95	.92	.89	.87	.84	.81	.79	.76	8.4	6.8	5.3	3.7	92.1
58 60	15.97	31.93	47.90	63.86	79.83	95.80	111.76	127.73	143.69	958.0	1915.9	2873.9	3831.8	4789.8

Lat.		Latitude 58° to 59°—Meridional arcs.						Latitude 58°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
58	00	30.939			1856.32						
	1	9	1	30.94	.33	1	1 856.3	0	1	985.6	0.1
	2	9	2	61.88	.33	2	3 712.7		2	1 971.2	0.5
	3	9	3	92.82	.34	3	5 569.0		3	2 956.8	1.1
	4	9	4	123.76	.34	4	7 425.3		4	3 942.3	1.9
58	05	30.939	5	154.71	1856.35	5	9 281.7	0	5	4 927.9	3.0
	6	9	6	185.65	.35	6	11 138.0		6	5 913.5	4.4
	7	9	7	216.59	.36	7	12 994.4		7	6 899.1	6.0
	8	9	8	247.53	.36	8	14 850.7		8	7 884.7	7.8
	9	39	9	278.47	.37	9	16 707.1		9	8 870.3	9.8
58	10	30.940	10	309.41	1856.37	10	18 563.5	0	10	9 855.8	12.2
	11	0	1	340.35	.38	11	20 419.9		15	14 783.7	27.4
	12	0	2	371.29	.38	12	22 276.2		20	19 711.6	48.6
	13	0	3	402.24	.39	13	24 132.6		25	24 639.5	76.0
	14	0	4	433.18	.39	14	25 989.0		30	29 567.3	109.4
58	15	30.940	15	464.12	1856.40	15	27 845.4	0	35	34 495.0	148.9
	16	0	6	495.06	.40	16	29 701.8		40	39 422.8	194.5
	17	0	7	526.00	.41	17	31 558.2		45	44 350.4	246.2
	18	0	8	556.94	.41	18	33 414.6		50	49 278.0	303.9
	19	0	9	587.88	.42	19	35 271.0		55	54 205.5	367.7
58	20	30.940	20	618.82	1856.42	20	37 127.5	1	00	59 132.9	437.6
	21	0	1	649.77	.43	21	38 983.9		05	64 060.2	513.6
	22	1	2	680.71	.43	22	40 840.3		10	68 987.5	595.6
	23	1	3	711.65	.44	23	42 696.8		15	73 914.7	683.8
	24	1	4	742.59	.44	24	44 553.2		20	78 841.7	778.0
58	25	30.941	25	773.53	1856.45	25	46 409.6	1	25	83 768.6	878.3
	26	1	6	804.47	.45	26	48 266.1		30	88 695.4	984.6
	27	1	7	835.41	.46	27	50 122.6		35	93 622.0	1 097.1
	28	1	8	866.35	.46	28	51 979.0		40	98 548.5	1 215.6
	29	1	9	897.30	.47	29	53 835.5		45	103 474.8	1 340.2
58	30	30.941	30	928.24	1856.47	30	55 692.0	1	50	108 401.0	1 470.8
	31	1	1	959.18	.48	31	57 548.4		55	113 327.1	1 607.6
	32	1	2	990.12	.48	32	59 404.9	2	00	118 253	1 750
	33	1	3	1 021.06	.49	33	61 261.4	3	00	177 347	3 938
	34	2	4	1 052.00	.49	34	63 117.9	4	00	236 402	7 000
58	35	30.942	35	1 082.94	1856.50	35	64 974.4	5	00	295 406	10 936
	36	2	6	1 113.88	.50	36	66 830.9	6	00	354 344	15 744
	37	2	7	1 144.83	.51	37	68 687.4	7	00	413 205	21 425
	38	2	8	1 175.77	.51	38	70 543.9	8	00	471 976	27 976
	39	2	9	1 206.71	.52	39	72 400.4	9	00	530 643	35 396
58	40	30.942	40	1 237.65	1856.52	40	74 256.9	10	00	589 194	43 684
	41	2	1	1 268.59	.53	41	76 113.5	11	00	647 616	52 837
	42	2	2	1 299.53	.53	42	77 970.0	12	00	705 896	62 854
	43	2	3	1 330.47	.54	43	79 826.5	13	00	764 021	73 733
	44	2	4	1 361.41	.54	44	81 683.1	14	00	821 979	85 470
58	45	30.942	45	1 392.35	1856.55	45	83 539.6	15	00	879 757	98 064
	46	3	6	1 423.30	.55	46	85 396.2	16	00	937 342	111 512
	47	3	7	1 454.24	.56	47	87 252.7	17	00	994 722	125 811
	48	3	8	1 485.18	.56	48	89 109.3	18	00	1 051 884	140 957
	49	3	9	1 516.12	.57	49	90 965.8	19	00	1 108 815	156 948
58	50	30.943	50	1 547.06	1856.57	50	92 822.4	20	00	1 165 504	173 780
	51	3	1	1 578.00	.58	51	94 679.0	21	00	1 221 937	191 449
	52	3	2	1 608.94	.58	52	96 535.6	22	00	1 278 103	209 951
	53	3	3	1 639.88	.59	53	98 392.1	23	00	1 333 988	229 282
	54	3	4	1 670.83	.59	54	100 248.7	24	00	1 389 581	249 439
58	55	30.943	55	1 701.77	1856.59	55	102 105.3	25	00	1 444 870	270 416
	56	3	6	1 732.71	.60	56	103 961.9	26	00	1 499 843	292 209
	57	3	7	1 763.65	.60	57	105 818.5	27	00	1 554 486	314 813
	58	3	8	1 794.59	.61	58	107 675.1	28	00	1 608 789	338 224
	59	4	9	1 825.53	.61	59	109 531.8	29	00	1 662 740	362 436
58	60	30.944	60	1 856.47	1856.62	60	111 388.4	30	00	1 716 327	387 443

Latitude 59° to 60°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
59 00	15.97	31.93	47.90	63.86	79.83	95.80	111.76	127.73	143.69	958.0	1915.9	2873.9	3831.8	4789.8
1	.96	.92	.88	.83	.79	.75	.71	.67	.62	7.5	5.0	2.5	30.0	7.5
2	.95	.90	.85	.80	.75	.70	.65	.61	.55	7.0	4.1	71.1	28.1	5.2
3	.94	.89	.83	.77	.71	.66	.60	.55	.48	6.6	3.1	69.7	6.3	2.8
4	.94	.87	.81	.74	.67	.61	.54	.48	.41	6.1	2.2	8.3	4.4	80.5
59 05	15.93	31.85	47.78	63.71	79.63	95.56	111.49	127.42	143.34	955.6	1911.3	2866.9	3822.6	4778.2
6	.92	.84	.76	.67	.60	.52	.44	.36	.28	5.2	10.4	5.5	20.7	5.9
7	.91	.82	.74	.65	.56	.47	.38	.30	.21	4.7	09.5	4.1	18.9	3.6
8	.90	.81	.71	.62	.52	.43	.33	.23	.14	4.3	8.5	2.8	7.0	71.3
9	.90	.79	.69	.58	.48	.38	.27	.17	.07	3.8	7.6	1.4	5.1	68.9
59 10	15.89	31.78	47.67	63.55	79.44	95.33	111.22	127.11	143.00	953.3	1906.7	2860.0	3813.3	4766.6
11	.88	.76	.64	.52	.40	.29	.17	7.05	2.93	2.9	5.8	58.6	11.4	4.3
12	.87	.75	.62	.49	.36	.24	.11	6.99	.86	2.4	4.8	7.2	09.6	62.0
13	.87	.73	.60	.46	.33	.19	.06	.92	.79	1.9	3.9	5.8	7.7	59.7
14	.86	.72	.57	.43	.29	.15	1.00	.86	.72	1.5	2.9	4.4	5.9	7.3
59 15	15.85	31.70	47.55	63.40	79.25	95.10	110.95	126.80	142.65	951.0	1902.0	2853.0	3804.0	4755.0
16	.84	.68	.53	.37	.21	.05	.90	.74	.58	0.5	1.1	1.6	2.2	2.7
17	.83	.67	.50	.34	.17	5.00	.84	.68	.51	50.1	900.2	50.2	800.3	50.4
18	.83	.65	.48	.31	.14	4.95	.79	.61	.44	49.6	899.2	48.8	798.4	48.1
19	.82	.64	.46	.28	.10	.91	.73	.55	.37	9.1	8.3	7.4	6.6	5.7
59 20	15.81	31.62	47.43	63.25	79.06	94.87	110.68	126.49	142.30	948.7	1897.4	2846.0	3794.7	4743.4
21	.80	.61	.41	.22	9.02	.82	.63	.43	.23	8.2	6.5	4.6	2.9	41.1
22	.80	.59	.39	.19	8.98	.78	.57	.37	.16	7.8	5.5	3.3	91.0	38.8
23	.79	.58	.36	.15	.94	.73	.52	.30	.09	7.3	4.6	1.9	89.2	6.4
24	.78	.56	.34	.12	.90	.68	.46	.24	2.02	6.8	3.6	40.5	7.3	4.1
59 25	15.77	31.55	47.32	63.09	78.87	94.64	110.41	126.18	141.96	946.4	1892.7	2839.1	3785.4	4731.8
26	.76	.53	.29	.06	.83	.59	.36	.12	.89	5.9	1.8	7.7	3.6	29.5
27	.76	.52	.27	.03	.79	.54	.30	6.06	.82	5.4	90.9	6.3	81.7	7.1
28	.75	.50	.25	3.00	.75	.50	.25	5.99	.75	5.0	89.9	4.9	79.8	4.8
29	.74	.49	.22	2.97	.71	.45	.19	.93	.68	4.5	9.0	3.5	8.0	2.5
59 30	15.73	31.47	47.20	62.94	78.67	94.40	110.14	125.87	141.61	944.0	1888.1	2832.1	3776.1	4720.2
31	.72	.45	.18	.91	.63	.36	.09	.81	.54	3.6	7.2	30.7	4.3	17.8
32	.72	.44	.15	.87	.59	.31	.03	.75	.47	3.1	6.2	29.3	2.4	5.5
33	.71	.42	.13	.84	.55	.26	10.98	.68	.40	2.6	5.3	7.9	70.5	3.2
34	.70	.41	.11	.81	.51	.22	09.92	.62	.33	2.2	4.3	6.5	68.7	10.8
59 35	15.70	31.39	47.08	62.78	78.48	94.17	109.87	125.56	141.26	941.7	1883.4	2825.1	3766.8	4708.5
36	.69	.38	.06	.75	.44	.12	.81	.50	.19	1.2	2.5	3.7	4.9	6.2
37	.68	.36	.04	.72	.40	.08	.76	.44	.12	0.8	1.6	2.3	3.1	3.9
38	.67	.34	7.02	.68	.36	4.03	.70	.37	1.05	40.3	80.6	20.9	61.2	701.5
39	.66	.33	6.99	.65	.32	3.98	.64	.31	0.97	39.8	79.7	19.5	59.4	699.2
59 40	15.66	31.31	46.97	62.62	78.28	93.94	109.59	125.25	140.91	939.4	1878.8	2818.1	3757.5	4696.9
41	.65	.30	.95	.59	.24	.89	.54	.19	.84	8.9	7.8	6.7	5.6	4.5
42	.64	.28	.92	.56	.20	.84	.48	.13	.77	8.4	6.9	5.3	3.8	92.2
43	.63	.27	.90	.53	.17	.80	.43	.06	.70	8.0	6.0	3.9	1.9	89.9
44	.63	.25	.88	.50	.12	.75	.37	5.00	.63	7.5	5.0	2.5	50.0	7.5
59 45	15.62	31.23	46.85	62.47	78.09	93.70	109.32	124.94	140.56	937.0	1874.1	2811.1	3748.2	4685.2
46	.61	.22	.83	.44	.05	.66	.27	.88	.49	6.6	3.2	09.7	6.3	2.9
47	.60	.20	.81	.40	8.01	.61	.21	.81	.42	6.1	2.2	8.3	4.4	80.5
48	.59	.19	.78	.38	7.97	.56	.16	.75	.35	5.6	1.3	6.9	2.6	78.2
49	.59	.17	.76	.34	.93	.52	.10	.69	.28	5.2	70.3	5.5	40.7	5.9
59 50	15.58	31.16	46.74	62.31	77.89	93.47	109.05	124.63	140.21	934.7	1869.4	2804.1	3738.8	4673.6
51	.57	.14	.71	.28	.85	.42	9.00	.57	.14	4.2	8.5	02.7	7.0	71.2
52	.56	.13	.69	.25	.81	.38	8.94	.50	.07	3.8	7.5	801.3	5.1	68.9
53	.56	.11	.67	.22	.77	.33	.89	.44	40.00	3.3	6.6	799.9	3.2	6.5
54	.55	.09	.64	.18	.73	.28	.83	.37	39.92	2.8	5.7	8.5	31.4	4.2
59 55	15.54	31.08	46.62	62.15	77.70	93.24	108.78	124.31	139.86	932.4	1864.7	2797.1	3729.5	4661.9
56	.53	.06	.60	.12	.66	.19	.72	.25	.79	1.9	3.8	5.7	7.6	59.5
57	.52	.05	.57	.09	.62	.14	.67	.19	.72	1.4	2.9	4.3	5.8	7.2
58	.52	.03	.55	.06	.58	.10	.61	.13	.65	1.0	1.9	2.9	3.9	4.9
59	.51	.02	.52	.03	.54	.05	.56	.07	.58	0.5	1.0	1.5	2.0	2.5
59 60	15.50	31.00	46.50	62.00	77.50	93.00	108.50	124.00	139.51	930.0	1860.1	2790.1	3720.1	4650.2

Lat.	Latitude 59° to 60° -Meridional arcs.						Latitude 59°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
59 00	30.944			1856.62					
1	4	1	30.95	.62	1	1 856.6	0 1	958.0	0.1
2	4	2	61.89	.63	2	3 713.2	2	1 915.9	0.5
3	4	3	92.84	.63	3	5 569.9	3	2 873.9	1.1
4	4	4	123.78	.64	4	7 426.5	4	3 831.9	1.9
59 05	30.944	5	154.73	1856.64	5	9 283.2	0 5	4 789.8	3.0
6	4	6	185.68	.65	6	11 139.8	6	5 747.7	4.3
7	4	7	216.62	.65	7	12 996.4	7	6 705.7	5.9
8	4	8	247.57	.66	8	14 853.1	8	7 663.7	7.6
9	4	9	278.51	.66	9	16 709.8	9	8 621.6	9.7
59 10	30.944	10	309.46	1856.67	10	18 566.4	0 10	9 579.6	11.9
11	5	1	340.41	.67	1	20 423.1	15	14 369.3	26.9
12	5	2	371.35	.68	2	22 279.8	20	19 159.1	47.8
13	5	3	402.30	.68	3	24 136.5	25	23 948.8	74.6
14	5	4	433.25	.69	4	25 993.1	30	28 738.5	107.5
59 15	30.945	15	464.19	1856.69	15	27 849.8	0 35	33 528.1	146.3
16	5	6	495.14	.70	6	29 706.5	40	38 317.7	191.1
17	5	7	526.08	.70	7	31 563.2	45	43 107.2	241.8
18	5	8	557.03	.71	8	33 419.9	50	47 896.7	298.6
19	5	9	587.98	.71	9	35 276.6	55	52 686.1	361.2
59 20	30.945	20	618.92	1856.72	20	37 133.4	1 00	57 475.4	429.9
21	5	1	649.87	.72	1	38 990.1	05	62 264.6	504.5
22	5	2	680.81	.73	2	40 846.8	10	67 053.7	585.2
23	6	3	711.76	.73	3	42 703.5	15	71 842.7	671.7
24	6	4	742.71	.74	4	44 560.3	20	76 631.6	764.3
59 25	30.946	25	773.65	1856.74	25	46 417.0	1 25	81 420.4	862.8
26	6	6	804.60	.75	6	48 273.7	30	86 209.0	967.3
27	6	7	835.54	.75	7	50 130.5	35	90 997.5	1 077.8
28	6	8	866.49	.75	8	51 987.2	40	95 785.9	1 194.2
29	6	9	897.44	.76	9	53 844.0	45	100 574.1	1 316.6
59 30	30.946	30	928.38	1856.76	30	55 700.8	1 50	105 362.2	1 445.0
31	6	1	959.33	.77	1	57 557.5	55	110 150.1	1 579.3
32	6	2	990.27	.77	2	59 414.3	2 00	114 938	1 720
33	6	3	1 021.22	.78	3	61 271.1	3 00	172 375	3 869
34	6	4	1 052.17	.78	4	63 127.9	4 00	229 773	6 877
59 35	30.946	35	1 083.11	1856.79	35	64 984.6	5 00	287 120	10 744
36	7	6	1 114.06	.79	6	66 841.4	6 00	344 402	15 468
37	7	7	1 145.00	.80	7	68 698.2	7 00	401 608	21 048
38	7	8	1 175.95	.80	8	70 555.0	8 00	458 723	27 484
39	7	9	1 206.90	.81	9	72 411.8	9 00	515 736	34 773
59 40	30.947	40	1 237.84	1856.81	40	74 268.7	10 00	572 633	42 914
41	7	1	1 268.79	.82	1	76 125.5	11 00	629 403	51 906
42	7	2	1 299.74	.82	2	77 982.3	12 00	686 031	61 746
43	7	3	1 330.68	.83	3	79 839.1	13 00	742 506	72 432
44	7	4	1 361.63	.83	4	81 695.9	14 00	798 815	83 961
59 45	30.947	45	1 392.57	1856.84	45	83 552.8	15 00	854 945	96 332
46	7	6	1 423.52	.84	6	85 409.6	16 00	910 883	109 541
47	7	7	1 454.47	.85	7	87 266.5	17 00	966 618	123 585
48	8	8	1 485.41	.85	8	89 123.3	18 00	1 022 136	138 462
49	8	9	1 516.36	.86	9	90 980.2	19 00	1 077 426	154 167
59 50	30.948	50	1 547.30	1856.86	50	92 837.0	20 00	1 132 474	170 698
51	8	1	1 578.25	.87	1	94 693.9	21 00	1 187 269	188 050
52	8	2	1 609.20	.87	2	96 550.8	22 00	1 241 799	206 221
53	8	3	1 640.14	.88	3	98 407.6	23 00	1 296 050	225 205
54	8	4	1 671.09	.88	4	100 264.5	24 00	1 350 011	244 998
59 55	30.948	55	1 702.03	1856.88	55	102 121.4	25 00	1 403 671	265 597
56	8	6	1 732.98	.89	6	103 978.3	26 00	1 457 015	286 995
57	8	7	1 763.93	.89	7	105 835.2	27 00	1 510 034	309 190
58	8	8	1 794.87	.90	8	107 692.1	28 00	1 562 715	332 175
59	8	9	1 825.82	.90	9	109 549.0	29 00	1 615 047	355 946
59 60	30.948	60	1 856.76	1856.91	60	111 405.9	30 00	1 667 016	380 497

Latitude 60° to 61°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
60 00	15.50	31.00	46.50	62.00	77.50	93.00	108.50	124.00	139.51	930.0	1860.1	2790.1	3720.1	4650.2
1	.49	0.99	.48	1.97	.46	92.96	.45	123.94	.44	29.6	59.2	88.7	18.3	47.8
2	.48	.97	.45	.94	.42	.91	.39	.88	.37	9.1	8.2	7.3	6.4	5.5
3	.48	.96	.43	.91	.38	.86	.34	.81	.30	8.6	7.3	5.9	4.5	3.2
4	.47	.94	.41	.88	.34	.82	.28	.75	.23	8.2	6.3	4.5	2.6	40.8
60 05	15.46	30.92	46.38	61.84	77.31	92.77	108.23	123.69	139.15	927.7	1855.4	2783.1	3710.8	4638.5
6	.45	.91	.36	.81	.27	.72	.18	.63	.08	7.2	4.5	1.7	08.9	6.1
7	.44	.89	.34	.78	.23	.68	.12	.57	9.01	6.8	3.5	80.3	7.0	3.8
8	.44	.88	.31	.75	.19	.63	.07	.50	8.94	6.3	2.6	78.9	5.2	1.4
9	.43	.86	.29	.72	.15	.58	8.01	.44	.87	5.8	1.6	7.5	3.3	29.1
60 10	15.42	30.85	46.27	61.69	77.11	92.54	107.96	123.38	138.80	925.4	1850.7	2776.1	3701.4	4626.8
11	.41	.83	.24	.66	.07	.49	.91	.32	.73	4.9	49.8	4.7	699.5	4.4
12	.40	.81	.22	.63	7.03	.44	.85	.26	.66	4.4	8.8	3.2	7.7	22.1
13	.40	.80	.20	.60	6.99	.39	.80	.19	.59	3.9	7.9	1.8	5.8	19.7
14	.39	.79	.17	.57	.95	.35	.74	.13	.52	3.5	6.9	70.4	3.9	7.4
60 15	15.38	30.77	46.15	61.53	76.92	92.30	107.69	123.07	138.45	923.0	1846.0	2769.0	3692.0	4615.0
16	.37	.75	.13	.50	.88	.25	.63	3.01	.38	2.5	5.1	7.6	90.2	2.7
17	.37	.74	.10	.47	.84	.21	.58	2.94	.31	2.1	4.1	6.2	88.3	10.4
18	.36	.72	.08	.44	.80	.16	.52	.88	.24	1.6	3.2	4.8	6.4	08.0
19	.35	.70	.06	.41	.76	.11	.47	.82	.17	1.1	2.2	3.4	4.5	5.7
60 20	15.34	30.69	46.03	61.38	76.72	92.07	107.41	122.76	138.10	920.7	1841.3	2762.0	3682.7	4603.3
21	.33	.67	6.01	.35	.68	2.02	.36	.70	8.03	0.2	40.4	60.6	80.8	601.0
22	.33	.66	5.99	.32	.64	1.97	.30	.63	7.96	19.7	39.4	59.2	78.9	598.6
23	.32	.64	.96	.28	.60	.93	.25	.57	.89	9.3	8.5	7.8	7.0	6.3
24	.31	.63	.94	.25	.56	.88	.19	.51	.82	8.8	7.5	6.4	5.1	3.9
60 25	15.30	30.61	45.92	61.22	76.53	91.83	107.14	122.44	137.75	918.3	1836.6	2754.9	3673.3	4591.6
26	.30	.59	.89	.19	.49	.78	.08	.38	.67	7.8	5.7	3.5	71.4	89.2
27	.29	.58	.87	.16	.45	.74	7.03	.32	.60	7.4	4.7	2.1	69.5	6.9
28	.28	.56	.85	.12	.41	.69	6.97	.25	.53	6.9	3.8	50.7	7.6	4.5
29	.28	.55	.82	.09	.37	.64	.92	.19	.46	6.4	2.8	49.3	5.7	82.2
60 30	15.27	30.53	45.80	61.06	76.33	91.60	106.86	122.13	137.39	916.0	1831.9	2747.9	3663.9	4579.8
31	.26	.51	.78	.03	.29	.55	.81	.07	.32	5.5	1.0	6.5	2.0	7.5
32	.25	.50	.75	1.00	.25	.50	.75	2.00	.25	5.0	30.0	5.1	60.1	5.1
33	.24	.48	.73	0.97	.21	.46	.70	1.94	.18	4.6	29.1	3.7	58.2	2.8
34	.23	.47	.70	.94	.17	.41	.64	.88	.11	4.1	8.1	2.3	6.3	70.4
60 35	15.23	30.45	45.68	60.91	76.14	91.36	106.59	121.82	137.04	913.6	1827.2	2740.8	3654.5	4568.1
36	.22	.44	.66	.87	.10	.31	.53	.75	6.97	3.1	6.3	39.4	2.6	5.7
37	.21	.42	.63	.84	.06	.27	.48	.69	.90	2.7	5.4	8.0	50.7	3.4
38	.21	.41	.61	.81	6.02	.22	.42	.63	.83	2.2	4.4	6.6	48.8	61.0
39	.20	.39	.59	.78	5.98	.17	.37	.56	.76	1.7	3.4	5.2	6.9	58.7
60 40	15.19	30.38	45.56	60.75	75.94	91.13	106.31	121.50	136.69	911.3	1822.5	2733.8	3645.0	4556.3
41	.18	.36	.54	.72	.90	.08	.26	.44	.62	0.8	1.6	2.4	3.2	4.0
42	.17	.35	.52	.69	.86	1.03	.20	.37	.55	10.3	20.6	31.0	41.3	51.6
43	.17	.33	.49	.66	.82	0.98	.15	.31	.48	09.8	19.7	29.5	39.4	49.2
44	.16	.32	.47	.63	.78	.94	.09	.25	.41	9.4	8.8	8.1	7.5	6.9
60 45	15.15	30.30	45.44	60.59	75.75	90.89	106.04	121.18	136.33	908.9	1817.8	2726.7	3635.6	4544.5
46	.14	.28	.42	.56	.71	.84	5.98	.12	.26	8.4	6.9	5.3	3.8	42.2
47	.13	.27	.40	.53	.67	.80	.93	.06	.19	8.0	5.9	3.9	1.8	39.8
48	.13	.25	.38	.50	.63	.75	.87	1.00	.12	7.5	5.0	2.5	30.0	7.5
49	.12	.24	.35	.47	.59	.70	.82	0.93	6.05	7.0	4.0	21.1	28.1	5.1
60 50	15.11	30.22	45.33	60.44	75.55	90.65	105.76	120.87	135.98	906.5	1813.1	2719.6	3626.2	4532.7
51	.10	.20	.30	.41	.51	.61	.71	.81	.91	6.1	2.2	8.2	4.3	30.4
52	.09	.19	.28	.37	.47	.56	.65	.75	.84	5.6	1.2	6.8	2.4	28.0
53	.09	.17	.26	.34	.43	.51	.60	.68	.77	5.1	10.3	5.4	20.6	5.7
54	.08	.16	.23	.31	.39	.47	.54	.62	.70	4.7	09.3	4.0	18.6	3.3
60 55	15.07	30.14	45.21	60.28	75.35	90.42	105.49	120.55	135.62	904.2	1808.4	2712.5	3616.7	4520.9
56	.06	.12	.19	.25	.31	.37	.43	.49	.56	3.7	7.4	11.2	4.9	18.6
57	.05	.11	.16	.22	.27	.32	.38	.43	.48	3.2	6.5	09.7	3.0	6.2
58	.05	.09	.14	.18	.23	.28	.32	.37	.41	2.8	5.6	8.3	11.1	3.9
59	.04	.08	.11	.15	.19	.23	.27	.30	.34	2.3	4.6	6.9	09.2	11.5
60 60	15.03	30.06	45.09	60.12	75.15	90.18	105.21	120.24	135.27	901.8	1803.7	2705.5	3607.3	4509.1

Lat.		Latitude 60° to 61°—Meridional arcs.						Latitude 60°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
60	00	30.948			1856.91						
	1	9	1	30.95	.91	1	1 856.9	0	1	930.0	0.1
	2	9	2	61.90	.92	2	3 713.8		2	1 860.1	0.5
	3	9	3	92.85	.92	3	5 570.7		3	2 790.1	1.1
	4	9	4	123.80	.93	4	7 427.7		4	3 720.2	1.9
60	05	30.949	5	154.75	1856.93	5	9 284.6	0	5	4 650.2	2.9
	6	9	6	185.71	.94	6	11 141.5		6	5 580.2	4.2
	7	9	7	216.66	.94	7	12 998.5		7	6 510.3	5.7
	8	9	8	247.61	.95	8	14 855.4		8	7 440.3	7.5
	9	9	9	278.56	.95	9	16 712.4		9	8 370.4	9.5
60	10	30.949	10	309.51	1856.96	10	18 569.3	0	10	9 300.4	11.7
	11	9	1	340.46	.96	1	20 426.3		15	13 950.5	26.4
	12	49	2	371.41	.97	2	22 283.2		20	18 600.6	46.9
	13	50	3	402.36	.97	3	24 140.2		25	23 250.7	73.2
	14	0	4	433.31	.98	4	25 997.2		30	27 900.8	105.4
60	15	30.950	15	464.26	1856.98	15	27 854.2	0	35	32 550.8	143.5
	16	0	6	495.21	.98	6	29 711.1		40	37 200.8	187.4
	17	0	7	526.16	.99	7	31 568.1		45	41 850.7	237.2
	18	0	8	557.12	6.99	8	33 425.1		50	46 500.6	292.8
	19	0	9	588.07	7.00	9	35 282.1		55	51 150.3	354.3
60	20	30.950	20	619.02	1857.00	20	37 139.1	1	00	55 800.0	421.7
	21	0	1	649.97	.01	1	38 996.1		05	60 449.6	494.9
	22	0	2	680.92	.01	2	40 853.1		10	65 099.2	574.0
	23	0	3	711.87	.02	3	42 710.1		15	69 738.6	658.9
	24	0	4	742.82	.02	4	44 567.2		20	74 397.9	749.7
60	25	30.950	25	773.77	1857.03	25	46 424.2	1	25	79 047.0	846.4
	26	1	6	804.72	.03	6	48 281.2		30	83 696.1	948.8
	27	1	7	835.67	.04	7	50 138.2		35	88 345.0	1 057.1
	28	1	8	866.62	.04	8	51 995.3		40	92 993.8	1 171.3
	29	1	9	897.57	.05	9	53 852.3		45	97 642.4	1 291.3
60	30	30.951	30	928.53	1857.05	30	55 709.4	1	50	102 290.9	1 417.2
	31	1	1	959.48	.06	1	57 566.4		55	106 939.2	1 549.0
	32	1	2	990.43	.06	2	59 423.5	2	00	111 587	1 687
	33	1	3	1 021.38	.07	3	61 280.6	3	00	167 349	3 795
	34	1	4	1 052.33	.07	4	63 137.6	4	00	223 073	6 745
60	35	30.951	35	1 083.28	1857.07	35	64 994.7	5	00	278 745	10 538
	36	1	6	1 114.23	.08	6	66 851.8	6	00	334 354	15 172
	37	1	7	1 145.18	.08	7	68 708.9	7	00	389 887	20 645
	38	1	8	1 176.13	.09	8	70 566.0	8	00	445 330	26 957
	39	2	9	1 207.08	.09	9	72 423.1	9	00	500 672	34 107
60	40	30.952	40	1 238.03	1857.10	40	74 280.1	10	00	555 899	42 092
	41	2	1	1 268.98	.10	1	76 137.2	11	00	611 000	50 911
	42	2	2	1 299.94	.11	2	77 994.4	12	00	665 961	60 562
	43	2	3	1 330.89	.11	3	79 851.5	13	00	720 769	71 043
	44	2	4	1 361.84	.12	4	81 708.6	14	00	775 413	82 350
60	45	30.952	45	1 392.79	1857.12	45	83 565.7	15	00	829 880	94 482
	46	2	6	1 423.74	.13	6	85 422.8	16	00	884 157	107 436
	47	2	7	1 454.69	.13	7	87 280.0	17	00	938 232	121 209
	48	2	8	1 485.64	.14	8	89 137.1	18	00	992 093	135 798
	49	2	9	1 516.59	.14	9	90 994.2	19	00	1 045 727	151 199
60	50	30.952	50	1 547.54	1857.15	50	92 851.4	20	00	1 099 123	167 409
	51	3	1	1 578.49	.15	1	94 708.5	21	00	1 152 267	184 424
	52	3	2	1 609.44	.15	2	96 565.7	22	00	1 205 148	202 241
	53	3	3	1 640.40	.16	3	98 422.8	23	00	1 257 753	220 854
	54	3	4	1 671.35	.16	4	100 280.0	24	00	1 310 072	240 261
60	55	30.953	55	1 702.30	1857.17	55	102 137.2	25	00	1 362 091	260 456
	56	3	6	1 733.25	.17	6	103 994.3	26	00	1 413 798	281 436
	57	3	7	1 764.20	.18	7	105 851.5	27	00	1 465 183	303 194
	58	3	8	1 795.15	.18	8	107 708.7	28	00	1 516 233	325 726
	59	3	9	1 826.10	.19	9	109 565.9	29	00	1 566 937	349 028
60	60	30.953	60	1 857.05	1857.19	60	111 423.1	30	00	1 617 283	373 093

Latitude 61° to 62°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
61 00	15.03	30.06	45.09	60.12	75.15	90.18	105.21	120.24	135.27	901.8	1803.7	2705.5	3607.3	4509.1
1	.02	.05	.07	.09	.11	.14	.16	.18	.20	1.4	2.7	4.1	5.4	6.8
2	.01	.03	.04	.06	.07	.09	.10	.12	.13	0.9	1.8	2.6	3.5	4.4
3	.01	.01	.02	.03	5.03	90.04	5.05	20.05	5.06	900.4	800.8	701.2	601.6	502.0
4	5.00	30.00	5.00	60.00	4.99	89.99	4.99	19.99	4.99	899.9	799.9	699.8	599.7	499.7
61 05	14.99	29.98	44.97	59.96	74.96	89.95	104.94	119.93	134.91	899.5	1798.9	2698.4	3597.9	4497.3
6	.98	.97	.95	.93	.92	.90	.88	.87	.85	9.0	8.0	7.0	6.0	5.0
7	.97	.95	.93	.90	.88	.85	.83	.80	.78	8.5	7.0	5.6	4.1	2.6
8	.97	.93	.90	.87	.84	.80	.77	.74	.70	8.0	6.1	4.1	2.2	90.2
9	.96	.92	.88	.84	.80	.76	.72	.67	.63	7.6	5.1	2.7	90.3	87.9
61 10	14.95	29.90	44.85	59.81	74.76	89.71	104.66	119.61	134.56	897.1	1794.2	2691.3	3588.4	4485.5
11	.94	.89	.83	.78	.72	.66	.61	.55	.49	6.6	3.3	89.9	6.5	3.1
12	.94	.87	.81	.74	.68	.62	.55	.49	.42	6.2	2.3	8.5	4.6	80.8
13	.93	.86	.78	.71	.64	.57	.50	.42	.35	5.7	1.4	7.0	2.7	78.4
14	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	90.4	5.6	80.8	6.0
61 15	14.91	29.82	44.74	59.65	74.56	89.47	104.39	119.30	134.21	894.7	1789.5	2684.2	3578.9	4473.6
16	.90	.81	.71	.62	.52	.43	.33	.23	.14	4.3	8.5	2.8	7.0	71.3
17	.90	.79	.69	.59	.48	.38	.28	.17	4.06	3.8	7.6	81.3	5.1	68.9
18	.89	.78	.67	.55	.44	.33	.22	.11	3.99	3.3	6.6	79.9	3.2	6.5
19	.88	.76	.64	.52	.40	.28	.17	9.04	.92	2.8	5.7	8.5	71.3	4.2
61 20	14.87	29.75	44.62	59.49	74.36	89.24	104.11	118.98	133.85	892.4	1784.7	2677.1	3569.4	4461.8
21	.86	.73	.59	.46	.32	.19	.06	.92	.78	1.9	3.8	5.7	7.5	59.4
22	.86	.71	.57	.43	.28	.14	4.00	.85	.71	1.4	2.8	4.2	5.6	7.1
23	.85	.70	.55	.40	.24	.09	3.95	.79	.64	0.9	1.9	2.8	3.7	4.7
24	.84	.68	.52	.36	.20	.05	.89	.73	.57	0.5	0.9	1.4	1.9	52.3
61 25	14.83	29.67	44.50	59.33	74.17	89.00	103.84	118.67	133.50	890.0	1780.0	2670.0	3560.0	4449.9
26	.83	.65	.48	.30	.13	8.95	.78	.60	.43	89.5	79.0	68.6	58.1	7.6
27	.82	.63	.45	.27	.09	.90	.72	.54	.35	9.0	8.1	7.1	6.2	5.2
28	.81	.62	.43	.24	.05	.86	.67	.48	.28	8.6	7.1	5.7	4.3	2.8
29	.80	.60	.40	.21	4.01	.81	.62	.41	.21	8.1	6.2	4.3	2.4	40.5
61 30	14.79	29.59	44.38	59.17	73.97	88.76	103.56	118.35	133.14	887.6	1775.2	2662.9	3550.5	4438.1
31	.79	.57	.36	.14	.93	.71	.50	.29	.07	7.1	4.3	1.4	48.6	5.7
32	.78	.56	.33	.11	.89	.67	.45	.22	3.00	6.7	3.3	60.0	6.7	3.3
33	.77	.54	.31	.08	.85	.62	.39	.16	2.93	6.2	2.4	58.6	4.8	31.0
34	.76	.52	.29	.05	.81	.57	.34	.10	.86	5.7	1.4	7.1	2.9	28.6
61 35	14.75	29.51	44.26	59.02	73.77	88.52	103.28	118.03	132.78	885.2	1770.5	2655.7	3541.0	4426.2
36	.75	.49	.24	8.98	.73	.48	.22	7.97	.71	4.8	69.5	4.3	39.1	3.8
37	.74	.48	.21	.95	.69	.43	.17	.91	.64	4.3	8.6	2.9	7.2	21.5
38	.73	.46	.19	.92	.65	.38	.11	.84	.57	3.8	7.6	1.4	5.3	19.1
39	.72	.44	.17	.89	.61	.33	.06	.78	.50	3.3	6.7	50.0	3.4	6.7
61 40	14.71	29.43	44.14	58.86	73.57	88.29	103.00	117.72	132.43	882.9	1765.7	2648.6	3531.5	4414.3
41	.71	.41	.12	.83	.53	.24	2.95	.65	.36	2.4	4.8	7.2	29.6	11.9
42	.70	.40	.10	.79	.49	.19	.89	.59	.29	1.9	3.8	5.7	7.7	09.6
43	.69	.38	.07	.76	.45	.14	.84	.53	.22	1.4	2.9	4.3	5.8	7.2
44	.68	.37	.05	.73	.41	.10	.78	.46	.15	1.0	1.9	2.9	3.8	4.8
61 45	14.67	29.35	44.02	58.70	73.38	88.05	102.73	117.40	132.07	880.5	1761.0	2641.5	3521.9	4402.4
46	.67	.33	4.00	.67	.34	8.00	.67	.33	2.00	80.0	60.0	40.0	20.0	400.0
47	.66	.32	3.98	.64	.30	7.95	.61	.27	1.93	79.5	59.1	38.6	18.1	397.7
48	.65	.30	.95	.60	.26	.91	.56	.21	.86	9.1	8.1	7.2	6.2	5.3
49	.64	.29	.93	.57	.22	.86	.51	.14	.79	8.6	7.2	5.7	4.3	2.9
61 50	14.64	29.27	43.91	58.54	73.18	87.81	102.45	117.08	131.72	878.1	1756.2	2634.3	3512.4	4390.5
51	.63	.25	.88	.51	.14	.76	.39	7.02	.65	7.6	5.2	2.9	10.5	88.1
52	.62	.24	.86	.48	.10	.72	.34	6.95	.58	7.2	4.3	1.5	08.6	5.8
53	.61	.22	.83	.44	.06	.67	.28	.89	.50	6.7	3.3	30.0	6.7	3.4
54	.60	.21	.81	.41	3.02	.62	.23	.83	.43	6.2	2.4	28.6	4.8	81.0
61 55	14.60	29.19	43.79	58.38	72.98	87.57	102.17	116.76	131.36	875.7	1751.4	2627.2	3502.9	4378.6
56	.59	.17	.76	.35	.94	.52	.11	.70	.29	5.2	50.5	5.7	501.0	6.2
57	.58	.16	.74	.32	.90	.48	.06	.64	.22	4.8	49.5	4.3	499.1	3.8
58	.57	.14	.72	.29	.86	.43	2.00	.57	.14	4.3	8.6	2.9	7.2	71.5
59	.56	.13	.69	.25	.82	.38	1.95	.51	.07	3.8	7.6	1.4	5.3	69.1
61 60	14.56	29.11	43.67	58.22	72.78	87.33	101.89	116.44	131.00	873.3	1746.7	2620.0	3493.4	4366.7

Lat.	Latitude 61° to 62°—Meridional arcs.						Latitude 61°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
61 00	30.953			1857.19					
1	3	1	30.96	.20	1	1 857.2	0 1	901.8	0.1
2	3	2	61.91	.20	2	3 714.4	2	1 803.7	0.5
3	3	3	92.87	.21	3	5 571.6	3	2 705.5	1.0
4	4	4	123.82	.21	4	7 428.8	4	3 607.3	1.8
61 05	30.954	5	154.78	1857.22	5	9 286.0	0 5	4 509.1	2.9
6	4	6	185.73	.22	6	11 143.2	6	5 411.0	4.1
7	4	7	216.69	.22	7	13 000.5	7	6 312.8	5.6
8	4	8	247.64	.23	8	14 857.7	8	7 214.6	7.3
9	4	9	278.60	.23	9	16 714.9	9	8 116.4	9.3
61 10	30.954	10	309.56	1857.24	10	18 572.2	0 10	9 018.3	11.5
11	4	1	340.51	.24	1	20 429.4	15	13 527.4	25.8
12	4	2	371.47	.25	2	22 286.6	20	18 036.5	45.9
13	4	3	402.42	.25	3	24 143.9	25	22 545.5	71.7
14	4	4	433.38	.26	4	26 001.1	30	27 054.5	103.2
61 15	30.954	15	464.33	1857.26	15	27 858.4	0 35	31 563.5	140.5
16	4	6	495.29	.27	6	29 715.7	40	36 072.5	183.5
17	5	7	526.24	.27	7	31 572.9	45	40 581.3	232.3
18	5	8	557.20	.28	8	33 430.2	50	45 090.1	286.8
19	5	9	588.15	.28	9	35 287.5	55	49 598.9	347.0
61 20	30.955	20	619.11	1857.29	20	37 144.8	1 00	54 107.5	413.0
21	5	1	650.07	.29	1	39 002.1	05	58 616.1	484.7
22	5	2	681.02	.29	2	40 859.3	10	63 124.5	562.1
23	5	3	711.98	.30	3	42 716.6	15	67 632.9	645.3
24	5	4	742.93	.30	4	44 573.9	20	72 141.2	734.2
61 25	30.955	25	773.89	1857.31	25	46 431.2	1 25	76 649.3	828.8
26	5	6	804.84	.31	6	48 288.6	30	81 157.3	929.2
27	5	7	835.80	.32	7	50 145.9	35	85 665.2	1 035.3
28	5	8	866.75	.32	8	52 003.2	40	90 172.9	1 147.1
29	5	9	897.71	.33	9	53 860.5	45	94 680.5	1 264.6
61 30	30.956	30	928.67	1857.33	30	55 717.8	1 50	99 188.0	1 388.0
31	6	1	959.62	.34	1	57 575.2	55	103 695.3	1 517.1
32	6	2	990.58	.34	2	59 432.5	2 00	108 202	1 652
33	6	3	1 021.53	.35	3	61 289.9	3 00	162 271	3 716
34	6	4	1 052.49	.35	4	63 147.2	4 00	216 304	6 606
61 35	30.956	35	1 083.44	1857.35	35	65 004.6	5 00	270 285	10 320
36	6	6	1 114.40	.36	6	66 861.9	6 00	324 204	14 857
37	6	7	1 145.35	.36	7	68 719.3	7 00	378 047	20 217
38	6	8	1 176.31	.37	8	70 576.7	8 00	431 802	26 399
39	6	9	1 207.27	.37	9	72 434.0	9 00	485 456	33 400
61 40	30.956	40	1 238.22	1857.38	40	74 291.4	10 00	538 997	41 219
41	6	1	1 269.18	.38	1	76 148.8	11 00	592 413	49 855
42	6	2	1 300.13	.39	2	78 006.2	12 00	645 690	59 305
43	7	3	1 331.09	.39	3	79 863.6	13 00	698 817	69 567
44	7	4	1 362.04	.40	4	81 721.0	14 00	751 781	80 639
61 45	30.957	45	1 393.00	1857.40	45	83 578.4	15 00	804 570	92 518
46	7	6	1 423.95	.41	6	85 435.8	16 00	857 172	105 201
47	7	7	1 454.91	.41	7	87 293.2	17 00	909 574	118 686
48	7	8	1 485.87	.41	8	89 150.6	18 00	961 764	132 969
49	7	9	1 516.82	.42	9	91 008.0	19 00	1 013 729	148 048
61 50	30.957	50	1 547.78	1857.42	50	92 865.4	20 00	1 065 459	163 917
51	7	1	1 578.73	.43	1	94 722.8	21 00	1 116 940	180 575
52	7	2	1 609.69	.43	2	96 580.3	22 00	1 168 161	198 016
53	7	3	1 640.64	.44	3	98 437.7	23 00	1 219 110	216 237
54	7	4	1 671.60	.44	4	100 295.2	24 00	1 269 775	235 234
61 55	30.957	55	1 702.55	1857.45	55	102 152.6	25 00	1 320 144	255 002
56	8	6	1 733.51	.45	6	104 010.0	26 00	1 370 205	275 537
57	8	7	1 764.46	.46	7	105 867.5	27 00	1 419 947	296 833
58	8	8	1 795.42	.46	8	107 725.0	28 00	1 469 358	318 886
59	8	9	1 826.38	.46	9	109 582.4	29 00	1 518 426	341 691
61 60	30.958	60	1 857.33	1857.47	60	111 439.9	30 00	1 567 141	365 242

Latitude 62° to 63°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
62 00	14.56	29.11	43.67	58.22	72.78	87.33	101.89	116.45	131.00	873.3	1746.7	2620.0	3493.4	4366.7
1	.55	.10	.64	.19	.74	.29	.83	.38	0.93	2.9	5.7	18.6	91.4	4.3
2	.54	.08	.62	.16	.70	.24	.78	.32	.86	2.4	4.8	7.2	89.5	61.9
3	.53	.06	.60	.13	.66	.19	.72	.25	.79	1.9	3.8	5.7	7.6	59.5
4	.53	.05	.57	.10	.62	.14	.67	.19	.72	1.4	2.9	4.3	5.7	7.1
62 05	14.52	29.03	43.55	58.06	72.58	87.10	101.61	116.13	130.65	871.0	1741.9	2612.9	3483.8	4354.8
6	.51	.02	.52	.03	.54	.05	.55	.06	.57	0.5	0.9	1.4	1.9	2.4
7	.50	9.00	.50	8.00	.50	7.00	.50	6.00	.50	70.0	40.0	10.0	80.0	50.0
8	.49	8.98	.48	7.97	.46	6.95	.44	5.94	.43	69.5	39.0	08.6	78.1	47.6
9	.48	.97	.45	.94	.42	.90	.89	.87	.35	9.0	8.1	7.1	6.2	5.2
62 10	14.48	28.95	43.43	57.90	72.38	86.86	101.33	115.81	130.28	868.6	1737.1	2605.7	3474.3	4342.8
11	.47	.94	.40	.87	.34	.81	.28	.74	.21	8.1	6.1	4.3	2.3	40.4
12	.46	.92	.38	.84	.30	.76	.22	.68	.14	7.6	5.2	2.8	70.4	38.0
13	.45	.90	.36	.81	.26	.71	.17	.62	.07	7.1	4.2	1.4	68.5	5.6
14	.44	.89	.33	.78	.22	.67	.11	.55	30.00	6.7	3.3	600.0	6.6	3.3
62 15	14.44	28.87	43.31	57.74	72.18	86.62	101.05	115.49	129.93	866.2	1732.3	2598.5	3464.7	4330.9
16	.43	.86	.29	.71	.14	.57	1.00	.43	.85	5.7	1.4	7.1	2.8	28.5
17	.42	.84	.26	.68	.10	.52	0.94	.36	.78	5.2	30.4	5.6	60.9	6.1
18	.41	.82	.24	.65	.06	.47	.89	.30	.71	4.7	29.5	4.2	59.0	3.7
19	.40	.81	.21	.62	2.02	.43	.83	.23	.64	4.3	8.5	2.8	7.0	21.3
62 20	14.40	28.79	43.19	57.59	71.98	86.38	100.78	115.17	129.57	863.8	1727.6	2591.3	3455.1	4318.9
21	.39	.78	.17	.55	.94	.33	.72	.11	.50	3.3	6.6	89.9	3.2	6.5
22	.38	.76	.14	.52	.90	.28	.67	5.04	.43	2.8	5.7	8.5	51.3	4.1
23	.37	.74	.12	.49	.86	.23	.61	4.98	.35	2.3	4.7	7.0	49.4	11.7
24	.36	.73	.09	.46	.82	.19	.56	.92	.28	1.9	3.8	5.6	7.5	09.3
62 25	14.36	28.71	43.07	57.43	71.78	86.14	100.50	114.85	129.21	861.4	1722.8	2584.2	3445.6	4306.9
26	.35	.70	.05	.39	.74	.09	.44	.79	.14	0.9	1.8	2.7	3.6	4.5
27	.34	.68	.02	.36	.70	.04	.39	.72	9.07	0.4	20.9	81.3	41.7	302.1
28	.34	.67	3.00	.33	.66	6.00	.33	.66	8.99	60.0	19.9	79.9	39.8	299.8
29	.33	.65	2.97	.30	.62	5.95	.28	.60	.92	59.5	9.0	8.4	7.9	7.4
62 30	14.32	28.63	42.95	57.27	71.58	85.90	100.22	114.53	128.85	859.0	1718.0	2577.0	3436.0	4295.0
31	.31	.62	.93	.23	.54	.85	.16	.47	.78	8.5	7.0	5.5	4.1	2.6
32	.30	.60	.90	.20	.50	.80	.11	.40	.71	8.0	6.1	4.1	2.1	90.2
33	.29	.59	.88	.17	.46	.76	.05	.34	.63	7.6	5.1	2.7	30.2	87.8
34	.28	.57	.85	.14	.42	.71	100.00	.28	.56	7.1	4.2	71.2	28.3	5.4
62 35	14.28	28.55	42.83	57.11	71.38	85.66	99.94	114.21	128.49	856.6	1713.2	2569.8	3426.4	4283.0
36	.27	.54	.81	.07	.34	.61	.88	.15	.42	6.1	2.2	8.3	4.5	80.6
37	.26	.52	.78	.04	.30	.56	.83	.08	.35	5.6	1.3	6.9	2.5	78.2
38	.25	.51	.76	7.01	.26	.52	.77	4.02	.27	5.2	10.3	5.5	20.6	5.8
39	.24	.49	.73	6.98	.22	.47	.72	3.96	.20	4.7	09.4	4.0	18.7	3.4
62 40	14.24	28.47	42.71	56.95	71.18	85.42	99.66	113.89	128.13	854.2	1708.4	2562.6	3416.8	4271.0
41	.23	.45	.69	.91	.14	.36	.60	.83	8.06	3.6	7.4	61.1	4.9	68.6
42	.22	.44	.66	.88	.10	.32	.55	.76	7.99	3.2	6.5	59.7	2.9	6.2
43	.21	.43	.64	.85	.06	.28	.49	.70	.91	2.8	5.5	8.3	11.0	3.8
44	.20	.41	.61	.82	1.02	.23	.44	.64	.84	2.3	4.6	6.8	09.1	61.4
62 45	14.20	28.39	42.59	56.79	70.98	85.18	99.38	113.57	127.77	851.8	1703.6	2555.4	3407.2	4259.0
46	.19	.38	.57	.75	.94	.13	.32	.51	.70	1.3	2.6	3.9	5.3	6.6
47	.18	.36	.54	.72	.90	.08	.27	.44	.63	0.8	1.7	2.5	3.3	4.2
48	.17	.35	.52	.69	.86	5.04	.21	.38	.55	50.4	700.7	51.1	401.4	51.8
49	.16	.33	.49	.66	.82	4.99	.16	.32	.48	49.9	699.8	49.6	399.5	49.4
62 50	14.16	28.31	42.47	56.63	70.78	84.94	99.10	113.25	127.41	849.4	1698.8	2548.2	3397.6	4247.0
51	.15	.30	.45	.59	.74	.89	9.04	.19	.34	8.9	7.8	6.7	5.6	4.6
52	.14	.28	.42	.56	.70	.84	8.99	.12	.27	8.4	6.9	5.3	3.7	42.1
53	.13	.26	.40	.53	.66	.79	.93	.06	.19	7.9	5.9	3.8	91.8	39.7
54	.12	.25	.37	.50	.62	.75	.87	3.00	.12	7.5	5.0	2.4	89.9	7.3
62 55	14.12	28.23	42.35	56.47	70.58	84.70	98.82	112.93	127.05	847.0	1694.0	2541.0	3387.9	4234.9
56	.11	.22	.33	.43	.54	.65	.76	.87	6.98	6.5	3.0	39.5	6.0	2.5
57	.10	.20	.30	.40	.50	.60	.70	.80	.91	6.0	2.1	8.1	4.1	30.1
58	.09	.18	.28	.37	.46	.55	.64	.74	.83	5.5	1.1	6.6	2.2	27.7
59	.08	.17	.25	.34	.42	.51	.59	.67	.76	5.1	90.2	5.2	80.2	5.3
62 60	14.08	28.15	42.23	56.31	70.38	84.46	98.53	112.61	126.69	844.6	1689.2	2533.7	3378.3	4222.9

Lat.	Latitude 62° to 63°—Meridional arcs.						Latitude 62°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
62 00	30.958			1857.47					
1	8	1	30.96	.47	1	1 857.5	0 1	873.3	0.1
2	8	2	61.92	.48	2	3 714.9	2	1 746.7	0.4
3	8	3	92.88	.48	3	5 572.4	3	2 620.0	1.0
4	8	4	123.84	.49	4	7 429.9	4	3 493.4	1.8
62 05	30.958	5	154.80	1857.49	5	9 287.4	0 5	4 366.7	2.8
6	8	6	185.76	.50	6	11 144.9	6	5 240.0	4.0
7	8	7	216.72	.50	7	13 002.4	7	6 113.4	5.5
8	8	8	247.68	.51	8	14 859.9	8	6 986.7	7.2
9	9	9	278.64	.51	9	16 717.4	9	7 860.0	9.1
62 10	30.959	10	309.60	1857.52	10	18 574.9	0 10	8 733.4	11.2
11	9	1	340.56	.52	1	20 432.5	15	13 100.1	25.2
12	9	2	371.52	.52	2	22 290.0	20	17 466.7	44.9
13	9	3	402.48	.53	3	24 147.5	25	21 833.3	70.1
14	9	4	433.44	.53	4	26 005.0	30	26 199.9	100.9
62 15	30.959	15	464.40	1857.54	15	27 862.6	0 35	30 566.4	137.4
16	9	6	495.36	.54	6	29 720.1	40	34 932.9	179.5
17	9	7	526.32	.55	7	31 577.7	45	39 299.4	227.1
18	9	8	557.28	.55	8	33 435.2	50	43 665.7	280.4
19	9	9	588.24	.56	9	35 292.8	55	48 032.0	339.3
62 20	30.959	20	619.20	1857.56	20	37 150.3	1 00	52 398.3	403.8
21	9	1	650.16	.57	1	39 007.9	05	56 764.3	473.8
22	59	2	681.12	.57	2	40 865.5	10	61 130.4	549.5
23	60	3	712.08	.57	3	42 723.0	15	65 496.4	630.8
24	0	4	743.04	.58	4	44 580.6	20	69 862.2	717.7
62 25	30.960	25	774.00	1857.58	25	46 438.2	1 25	74 227.9	810.3
26	0	6	804.96	.59	6	48 295.8	30	78 593.5	908.4
27	0	7	835.92	.59	7	50 153.4	35	82 959.0	1 012.1
28	0	8	866.88	.60	8	52 011.0	40	87 324.3	1 121.5
29	0	9	897.84	.60	9	53 868.6	45	91 689.5	1 236.4
62 30	30.960	30	928.80	1857.61	30	55 726.2	1 50	96 054.5	1 357.0
31	0	1	959.76	.61	1	57 583.8	55	100 419.4	1 483.1
32	0	2	990.72	.61	2	59 441.4	2 00	104 784	1 615
33	0	3	1 021.68	.62	3	61 299.0	3 00	157 145	3 633
34	0	4	1 052.64	.62	4	63 156.6	4 00	209 469	6 458
62 35	30.960	35	1 083.60	1857.63	35	65 014.2	5 00	261 742	10 089
36	1	6	1 114.56	.63	6	66 871.9	6 00	313 954	14 525
37	1	7	1 145.52	.64	7	68 729.5	7 00	366 091	19 765
38	1	8	1 176.48	.64	8	70 587.1	8 00	418 142	25 807
39	1	9	1 207.44	.65	9	72 444.8	9 00	470 093	32 652
62 40	30.961	40	1 238.40	1857.65	40	74 302.4	10 00	521 932	40 296
41	1	1	1 269.36	.66	1	76 160.1	11 00	573 647	48 737
42	1	2	1 300.32	.66	2	78 017.7	12 00	625 226	57 975
43	1	3	1 331.28	.66	3	79 875.4	13 00	676 657	68 006
44	1	4	1 362.24	.67	4	81 733.1	14 00	727 927	78 829
62 45	30.961	45	1 393.20	1857.67	45	83 590.7	15 00	779 024	90 441
46	1	6	1 424.16	.68	6	85 448.4	16 00	829 936	102 838
47	1	7	1 455.12	.68	7	87 306.1	17 00	880 651	116 019
48	1	8	1 486.08	.69	8	89 163.8	18 00	931 157	129 980
49	2	9	1 517.04	.69	9	91 021.5	19 00	981 442	144 717
62 50	30.962	50	1 548.00	1857.70	50	92 879.2	20 00	1 031 494	160 227
51	2	1	1 578.96	.70	1	94 736.9	21 00	1 081 300	176 507
52	2	2	1 609.93	.70	2	96 594.6	22 00	1 130 850	193 552
53	2	3	1 640.89	.71	3	98 452.3	23 00	1 180 132	211 359
54	2	4	1 671.85	.71	4	100 310.1	24 00	1 229 133	229 923
62 55	30.962	55	1 702.81	1857.72	55	102 167.8	25 00	1 277 842	249 240
56	2	6	1 733.77	.72	6	104 025.5	26 00	1 326 248	269 306
57	2	7	1 764.73	.73	7	105 883.2	27 00	1 374 339	290 114
58	2	8	1 795.69	.73	8	107 741.0	28 00	1 422 103	311 662
59	2	9	1 826.65	.74	9	109 598.7	29 00	1 469 530	333 943
62 60	30.962	60	1 857.61	1857.74	60	111 456.4	30 00	1 516 608	356 952

Latitude 63° to 64°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
63 00	14.08	28.15	42.23	56.31	70.38	84.46	98.53	112.61	126.69	844.6	1689.2	2533.7	3378.3	4222.9
1	.07	.14	.21	.28	.34	.41	.47	.55	.62	4.1	8.2	2.3	6.4	20.5
2	.06	.12	.18	.24	.30	.36	.42	.48	.54	3.6	7.2	30.9	4.5	18.1
3	.05	.10	.16	.21	.26	.31	.36	.42	.47	3.1	6.3	29.4	2.6	5.7
4	.04	.09	.13	.18	.22	.27	.31	.35	.40	2.7	5.3	8.0	70.6	3.3
63 05	14.04	28.07	42.11	56.14	70.18	84.22	98.25	112.29	126.32	842.2	1684.4	2526.5	3368.7	4210.9
6	.03	.05	.08	.11	.14	.17	.19	.23	.25	1.7	3.4	5.0	6.8	08.4
7	.02	.04	.06	.08	.10	.12	.14	.16	.18	1.2	2.4	3.6	4.8	6.0
8	.01	.02	.04	.05	.06	.07	.08	.10	.11	0.7	1.4	2.2	2.9	3.6
9	.00	8.01	2.01	6.02	70.02	4.02	8.03	2.03	6.04	40.2	80.5	20.7	61.0	201.2
63 10	14.00	27.99	41.99	55.98	69.98	83.98	97.97	111.97	125.96	839.8	1679.5	2519.3	3359.0	4198.8
11	3.99	.97	.96	.95	.94	.93	.91	.91	.89	9.3	8.6	7.8	7.1	6.4
12	.98	.96	.94	.92	.90	.88	.86	.84	.82	8.8	7.6	6.4	5.2	4.0
13	.97	.94	.92	.89	.86	.83	.80	.78	.75	8.3	6.6	5.0	3.3	91.6
14	.96	.93	.89	.86	.82	.78	.75	.71	.68	7.8	5.7	3.5	51.3	89.2
63 15	13.96	27.91	41.87	55.82	69.78	83.73	97.69	111.65	125.60	837.3	1674.7	2512.0	3349.4	4186.7
16	.95	.89	.84	.79	.74	.69	.63	.58	.53	6.9	3.7	10.6	7.5	4.3
17	.94	.88	.82	.76	.70	.64	.58	.52	.46	6.4	2.8	09.1	5.5	81.9
18	.93	.86	.80	.73	.66	.59	.52	.45	.38	5.9	1.8	7.7	3.6	79.5
19	.92	.85	.77	.69	.62	.54	.47	.39	.31	5.4	70.8	6.3	41.7	7.1
63 20	13.92	27.83	41.75	55.66	69.58	83.49	97.41	111.32	125.24	834.9	1669.9	2504.8	3339.8	4174.7
21	.91	.81	.72	.63	.54	.45	.35	.26	.17	4.5	8.9	3.4	7.8	72.3
22	.90	.80	.70	.60	.50	.40	.30	.19	.10	4.0	8.0	1.9	5.9	69.9
23	.89	.78	.67	.57	.46	.35	.24	.13	5.02	3.5	7.0	500.4	3.9	7.4
24	.88	.77	.65	.53	.42	.30	.18	.07	4.95	3.0	6.0	499.0	2.0	5.0
63 25	13.88	27.75	41.63	55.50	69.38	83.25	97.13	111.00	124.88	832.5	1665.0	2497.6	3330.1	4162.6
26	.87	.73	.60	.47	.34	.20	.07	0.94	.81	2.0	4.0	6.1	28.2	60.2
27	.86	.72	.58	.44	.30	.16	7.02	.87	.74	1.6	3.1	4.7	6.2	57.8
28	.85	.70	.55	.40	.26	.11	6.96	.81	.66	1.1	2.2	3.2	4.3	5.4
29	.84	.69	.53	.37	.22	.06	.91	.74	.59	0.6	1.2	1.7	2.3	2.9
63 30	13.84	27.67	41.51	55.34	69.18	83.01	96.85	110.68	124.52	830.1	1660.2	2490.3	3320.4	4150.5
31	.83	.65	.48	.31	.14	2.96	.79	.62	.45	29.6	59.2	88.9	18.5	48.1
32	.82	.64	.46	.28	.10	.91	.74	.55	.37	9.1	8.3	7.4	6.6	5.7
33	.81	.62	.43	.24	.06	.87	.68	.49	.30	8.7	7.3	6.0	4.6	3.3
34	.80	.61	.41	.21	9.02	.82	.62	.42	.23	8.2	6.3	4.5	2.7	40.8
63 35	13.79	27.59	41.38	55.18	68.97	82.77	96.56	110.35	124.15	827.7	1655.4	2483.0	3310.7	4138.4
36	.79	.57	.36	.15	.93	.72	.51	.30	.08	7.2	4.4	1.6	08.8	6.0
37	.78	.56	.34	.12	.89	.67	.45	.23	4.01	6.7	3.4	80.2	6.9	3.6
38	.77	.54	.31	.08	.85	.62	.39	.17	3.94	6.2	2.5	78.7	5.0	31.2
39	.76	.53	.29	.05	.81	.57	.34	.10	.86	5.7	1.5	7.2	3.0	28.7
63 40	13.75	27.51	41.26	55.02	68.77	82.53	96.28	110.04	123.79	825.3	1650.5	2475.8	3301.0	4126.3
41	.75	.49	.24	4.99	.73	.48	.22	09.97	.71	4.8	49.6	4.3	299.1	3.9
42	.74	.48	.21	.95	.69	.43	.17	.91	.64	4.3	8.6	2.9	7.2	21.5
43	.73	.46	.19	.92	.65	.38	.11	.84	.57	3.8	7.6	1.4	5.2	19.0
44	.72	.45	.17	.89	.61	.33	.06	.78	.50	3.3	6.6	70.0	3.3	6.6
63 45	13.71	27.43	41.14	54.86	68.57	82.28	96.00	109.71	123.43	822.8	1645.7	2468.5	3291.4	4114.2
46	.70	.41	.12	.82	.53	.24	5.94	.65	.35	2.4	4.7	7.1	89.4	11.8
47	.70	.40	.09	.79	.49	.19	.89	.58	.28	1.9	3.8	5.6	7.5	09.4
48	.69	.38	.07	.76	.45	.14	.83	.52	.21	1.4	2.8	4.1	5.5	6.9
49	.68	.36	.04	.73	.41	.09	.77	.45	.13	0.9	1.8	2.7	3.6	4.5
63 50	13.67	27.35	41.02	54.69	68.37	82.04	95.72	109.39	123.06	820.4	1640.8	2461.3	3281.7	4102.1
51	.67	.33	1.00	.66	.33	1.99	.66	.33	2.99	19.9	39.9	59.8	79.8	099.7
52	.66	.31	0.97	.63	.29	.94	.60	.26	.92	9.4	8.9	8.3	7.8	7.2
53	.65	.30	.95	.60	.25	.90	.55	.20	.84	9.0	7.9	6.9	5.8	4.8
54	.64	.28	.92	.56	.21	.85	.49	.13	.77	8.5	7.0	5.4	3.9	92.4
63 55	13.63	27.27	40.90	54.53	68.16	81.80	95.43	109.06	122.70	818.0	1636.0	2453.9	3271.9	4089.9
56	.62	.25	.88	.50	.12	.75	.38	9.00	.62	7.5	5.0	2.5	70.0	7.5
57	.62	.23	.85	.47	.08	.70	.32	8.94	.55	7.0	4.0	51.1	68.1	5.1
58	.61	.22	.83	.44	.04	.66	.25	.87	.48	6.5	3.1	49.6	6.2	2.7
59	.60	.20	.80	.40	8.00	.61	.20	.81	.41	6.1	2.1	8.1	4.2	80.2
63 60	13.59	27.19	40.78	54.37	67.96	81.56	95.15	108.74	122.33	815.6	1631.1	2446.7	3262.2	4077.8

Lat.	Latitude 63° to 64°—Meridional arcs.						Latitude 63°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
63 00	30.962			1857.74					
1	2	1	30.96	.74	1	1 857.7	0 1	844.6	0.1
2	2	2	61.93	.75	2	3 715.5	2	1 689.2	0.4
3	3	3	92.89	.75	3	5 573.2	3	2 533.7	1.0
4	3	4	123.86	.76	4	7 431.0	4	3 378.3	1.7
63 05	30.963	5	154.82	1857.76	5	9 288.8	0 5	4 222.9	2.7
6	3	6	185.79	.77	6	11 146.5	6	5 067.5	3.9
7	3	7	216.75	.77	7	13 004.3	7	5 912.1	5.4
8	3	8	247.72	.78	8	14 862.1	8	6 756.6	7.0
9	3	9	278.68	.78	9	16 719.8	9	7 601.2	8.9
63 10	30.963	10	309.65	1857.78	10	18 577.6	0 10	8 445.8	11.0
11	3	1	340.61	.79	1	20 435.4	15	12 668.7	24.6
12	3	2	371.57	.79	2	22 293.2	20	16 891.6	43.8
13	3	3	402.54	.80	3	24 151.0	25	21 114.4	68.4
14	3	4	433.50	.80	4	26 008.8	30	25 337.2	98.5
63 15	30.963	15	464.47	1857.81	15	27 866.6	0 35	29 559.9	134.1
16	4	6	495.43	.81	6	29 724.4	40	33 782.6	175.1
17	4	7	526.40	.82	7	31 582.2	45	38 005.3	221.6
18	4	8	557.36	.82	8	33 440.0	50	42 227.9	273.6
19	4	9	588.33	.82	9	35 297.9	55	46 450.4	331.1
63 20	30.964	20	619.29	1857.83	20	37 155.7	1 00	50 672.8	394.0
21	4	1	650.26	.83	1	39 013.5	05	54 895.2	462.4
22	4	2	681.22	.84	2	40 871.4	10	59 117.4	536.3
23	4	3	712.18	.84	3	42 729.2	15	63 339.6	615.6
24	4	4	743.15	.85	4	44 587.0	20	67 561.6	700.4
63 25	30.964	25	774.11	1857.85	25	46 444.9	1 25	71 783.6	790.7
26	4	6	805.08	.86	6	48 302.7	30	76 005.4	886.5
27	4	7	836.04	.86	7	50 160.6	35	80 227.1	987.7
28	4	8	867.01	.86	8	52 018.5	40	84 448.6	1 094.4
29	4	9	897.80	.87	9	53 876.3	45	88 670.1	1 206.6
63 30	30.965	30	928.94	1857.87	30	55 734.2	1 50	92 891.3	1 324.2
31	5	1	959.90	.88	1	57 592.1	55	97 112.5	1 447.4
32	5	2	990.87	.88	2	59 450.0	2 00	101 333	1 576
33	5	3	1 021.83	.89	3	61 307.9	3 00	151 970	3 546
34	5	4	1 052.80	.89	4	63 165.7	4 00	202 569	6 302
63 35	30.965	35	1 083.76	1857.90	35	65 023.6	5 00	253 119	9 846
36	5	6	1 114.72	.90	6	66 881.5	6 00	303 608	14 175
37	5	7	1 145.69	.90	7	68 739.4	7 00	354 024	19 288
38	5	8	1 176.65	.91	8	70 597.3	8 00	404 354	25 185
39	5	9	1 207.62	.91	9	72 455.2	9 00	454 586	31 864
63 40	30.965	40	1 238.58	1857.92	40	74 313.2	10 00	504 709	39 323
41	5	1	1 269.55	.92	1	76 171.1	11 00	554 709	47 561
42	5	2	1 300.51	.93	2	78 029.0	12 00	604 575	56 575
43	6	3	1 331.48	.93	3	79 886.9	13 00	654 295	66 363
44	6	4	1 362.44	.94	4	81 744.9	14 00	703 857	76 924
63 45	30.966	45	1 393.41	1857.94	45	83 602.8	15 00	753 249	88 254
46	6	6	1 424.37	.94	6	85 460.7	16 00	802 458	100 350
47	6	7	1 455.33	.95	7	87 318.7	17 00	851 473	113 211
48	6	8	1 486.30	.95	8	89 176.6	18 00	900 283	126 832
49	6	9	1 517.26	.96	9	91 034.6	19 00	948 874	141 210
63 50	30.966	50	1 548.23	1857.96	50	92 892.6	20 00	997 237	156 343
51	6	1	1 579.19	.97	1	94 750.5	21 00	1 045 358	172 225
52	6	2	1 610.16	.97	2	96 608.5	22 00	1 093 226	188 854
53	6	3	1 641.12	.97	3	98 466.5	23 00	1 140 830	206 225
54	6	4	1 672.09	.98	4	100 324.4	24 00	1 188 158	224 335
63 55	30.966	55	1 703.05	1857.98	55	102 182.4	25 00	1 235 199	243 178
56	6	6	1 734.02	.99	6	104 040.4	26 00	1 281 941	262 750
57	7	7	1 764.98	7.99	7	105 898.4	27 00	1 328 373	283 047
58	7	8	1 795.94	8.00	8	107 756.4	28 00	1 374 483	304 064
59	7	9	1 826.91	.00	9	109 614.4	29 00	1 420 262	325 795
63 60	30.967	60	1 857.87	1858.00	60	111 472.4	30 00	1 465 696	348 235

Latitude 64° to 65°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
64 00	13.59	27.19	40.78	54.37	67.96	81.56	95.15	108.74	122.33	815.6	1631.1	2446.7	3262.2	4077.8
1	.58	.17	.75	.34	.92	.51	.09	.68	.26	5.1	30.1	5.2	60.3	5.4
2	.58	.15	.73	.31	.88	.46	5.03	.61	.19	4.6	29.2	3.8	58.4	2.9
3	.57	.14	.71	.27	.84	.41	4.98	.55	.11	4.1	8.2	2.3	6.4	70.5
4	.56	.12	.68	.24	.80	.36	.92	.48	2.04	3.6	7.3	40.9	4.5	68.1
64 05	13.55	27.10	40.66	54.21	67.76	81.31	94.87	108.42	121.97	813.1	1626.3	2439.4	3252.5	4065.7
6	.54	.09	.63	.18	.72	.26	.81	.35	.90	2.6	5.3	7.9	50.6	3.2
7	.54	.07	.61	.14	.68	.21	.75	.29	.82	2.1	4.3	6.5	48.6	60.8
8	.53	.06	.58	.11	.64	.17	.70	.22	.75	1.7	3.4	5.0	6.7	58.4
9	.52	.04	.56	.08	.60	.12	.64	.16	.68	1.2	2.4	3.6	4.7	5.9
64 10	13.51	27.02	40.54	54.05	67.56	81.07	94.58	108.09	121.60	810.7	1621.4	2432.1	3242.8	4053.5
11	.50	7.01	.51	4.01	.52	1.02	.53	8.03	.54	10.2	20.4	30.6	40.9	51.1
12	.49	6.99	.49	3.98	.48	0.97	.47	7.96	.46	09.7	19.4	29.2	38.9	48.6
13	.49	.97	.46	.95	.44	.92	.41	.90	.39	9.2	8.5	7.7	7.0	6.2
14	.48	.96	.44	.92	.40	.88	.35	.83	.31	8.8	7.5	6.3	5.0	3.8
64 15	13.47	26.94	40.41	53.88	67.35	80.83	94.30	107.77	121.24	808.3	1616.5	2424.8	3233.1	4041.3
16	.46	.93	.39	.85	.31	.78	.24	.70	.17	7.8	5.5	3.3	31.1	38.9
17	.45	.91	.37	.82	.27	.73	.18	.64	.09	7.3	4.6	1.9	29.2	6.5
18	.45	.89	.34	.79	.23	.68	.12	.57	1.02	6.8	3.6	20.4	7.2	4.0
19	.44	.88	.32	.75	.19	.63	.07	.51	0.95	6.3	2.7	19.0	5.3	31.6
64 20	13.43	26.86	40.29	53.72	67.15	80.58	94.01	107.45	120.88	805.8	1611.7	2417.5	3223.3	4029.2
21	.42	.84	.27	.69	.11	.53	3.96	.38	.80	5.3	10.7	6.0	21.4	6.7
22	.41	.83	.24	.66	.07	.49	.90	.31	.73	4.9	09.7	4.6	19.4	4.3
23	.41	.81	.22	.62	7.03	.44	.84	.25	.65	4.4	8.8	3.1	7.5	21.8
24	.40	.80	.19	.59	6.99	.39	.79	.18	.58	3.9	7.8	1.6	5.5	19.4
64 25	13.39	26.78	40.17	53.56	66.95	80.34	93.73	107.12	120.51	803.4	1606.8	2410.2	3213.6	4017.0
26	.38	.76	.15	.53	.91	.29	.67	7.05	.43	2.9	5.8	08.7	11.6	4.5
27	.37	.75	.12	.49	.87	.24	.62	6.99	.36	2.4	4.8	7.3	09.7	12.1
28	.37	.73	.10	.46	.83	.19	.56	.93	.29	1.9	3.9	5.8	7.7	09.7
29	.36	.71	.07	.43	.79	.14	.50	.86	.22	1.4	2.9	4.3	5.8	7.2
64 30	13.35	26.70	40.05	53.40	66.75	80.10	93.45	106.79	120.14	801.0	1601.9	2402.9	3203.8	4004.8
31	.34	.68	.02	.36	.71	.05	.39	.73	20.07	0.5	600.9	401.4	201.9	4002.3
32	.33	.67	40.00	.33	.67	80.00	.33	.66	19.99	800.0	599.9	399.9	199.9	3999.9
33	.33	.65	39.98	.30	.63	79.95	.28	.60	.92	799.5	9.0	8.5	8.0	7.5
34	.32	.63	.95	.27	.58	.90	.21	.53	.85	9.0	8.0	7.0	6.0	5.0
64 35	13.31	26.62	39.93	53.23	66.54	79.85	93.16	106.47	119.78	798.5	1597.0	2395.5	3194.1	3992.6
36	.30	.60	.90	.20	.50	.80	.10	.40	.70	8.0	6.0	4.1	2.1	90.1
37	.29	.58	.88	.17	.46	.75	3.05	.34	.63	7.5	5.1	2.6	90.2	87.7
38	.28	.57	.85	.14	.42	.71	2.99	.27	.56	7.1	4.1	91.2	88.2	5.3
39	.28	.55	.83	.10	.38	.66	.93	.21	.48	6.6	3.1	89.7	6.2	2.8
64 40	13.27	26.54	39.80	53.07	66.34	79.61	92.88	106.14	119.41	796.1	1592.2	2388.2	3184.3	3980.4
41	.26	.52	.78	.04	.30	.56	.82	.08	.34	5.6	1.2	6.8	2.3	77.9
42	.25	.50	.75	3.01	.26	.51	.76	6.01	.26	5.1	90.2	5.3	80.4	5.5
43	.24	.49	.73	2.97	.22	.46	.70	5.95	.19	4.6	89.3	3.8	78.4	3.0
44	.24	.47	.71	.94	.18	.41	.65	.88	.12	4.1	8.3	2.4	6.5	70.6
64 45	13.23	26.45	39.68	52.91	66.14	79.36	92.59	105.82	119.04	793.6	1587.3	2380.9	3174.5	3968.2
46	.22	.44	.66	.88	.09	.31	.53	.75	8.97	3.1	6.3	79.4	2.6	5.7
47	.21	.42	.63	.84	.05	.27	.48	.69	.90	2.7	5.3	8.0	70.6	3.3
48	.20	.41	.61	.81	6.01	.22	.42	.62	.82	2.2	4.4	6.5	68.7	60.8
49	.19	.39	.58	.78	5.97	.17	.36	.56	.75	1.7	3.4	5.0	6.7	58.4
64 50	13.19	26.37	39.56	52.75	65.93	79.12	92.30	105.49	118.68	791.2	1582.4	2373.6	3164.7	3955.9
51	.18	.36	.54	.71	.89	.07	.25	.43	.61	0.7	1.4	2.1	2.8	3.5
52	.17	.34	.51	.68	.85	9.02	.19	.36	.53	90.2	80.4	70.6	60.8	51.0
53	.16	.32	.49	.65	.81	8.97	.13	.30	.46	89.7	79.5	69.2	58.9	48.6
54	.15	.31	.46	.62	.77	.92	.08	.23	.38	9.2	8.5	7.7	6.9	6.1
64 55	13.15	26.29	39.44	52.58	65.73	78.87	92.02	105.17	118.31	788.7	1577.5	2366.2	3155.0	3943.7
56	.14	.27	.41	.55	.69	.82	1.96	.10	.24	8.2	6.5	4.7	3.0	41.2
57	.13	.26	.39	.52	.65	.78	.91	5.03	.16	7.8	5.5	3.3	51.0	38.8
58	.12	.24	.36	.48	.60	.73	.85	4.97	.09	7.3	4.6	1.8	49.1	6.3
59	.11	.23	.34	.45	.56	.68	.79	.90	8.02	6.8	3.6	60.8	7.1	3.9
64 60	13.10	26.21	39.31	52.42	65.52	78.63	91.73	104.84	117.94	786.3	1572.6	2358.9	3145.2	3931.5

Lat.	Latitude 64° to 65°—Meridional arcs.						Latitude 64°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
64 00	30.967			1858.00					
1	7	1	30.97	.01	1	1 858.0	0 1	815.6	0.1
2	7	2	61.94	.01	2	3 716.0	2	1 631.1	0.4
3	7	3	92.91	.02	3	5 574.0	3	2 446.7	1.0
4	7	4	123.88	.02	4	7 432.1	4	3 262.2	1.7
64 05	30.967	5	154.84	1858.03	5	9 290.1	0 5	4 077.8	2.7
6	7	6	185.81	.03	6	11 148.1	6	4 893.4	3.8
7	7	7	216.78	.04	7	13 006.1	7	5 708.9	5.2
8	7	8	247.75	.04	8	14 864.2	8	6 524.5	6.8
9	7	9	278.72	.04	9	16 722.2	9	7 340.1	8.6
64 10	30.967	10	309.69	1858.05	10	18 580.3	0 10	8 155.6	10.7
11	8	1	340.66	.05	1	20 438.3	15	12 233.4	24.0
12	8	2	371.63	.06	2	22 296.4	20	16 311.2	42.6
13	8	3	402.60	.06	3	24 154.4	25	20 388.9	66.6
14	8	4	433.56	.07	4	26 012.5	30	24 466.6	95.9
64 15	30.968	15	464.53	1858.07	15	27 870.6	0 35	28 544.3	130.6
16	8	6	495.50	.07	6	29 728.6	40	32 621.9	170.6
17	8	7	526.47	.08	7	31 586.7	45	36 699.5	215.9
18	8	8	557.44	.08	8	33 444.8	50	40 777.0	266.5
19	8	9	588.41	.09	9	35 302.9	55	44 854.4	322.5
64 20	30.968	20	619.38	1858.09	20	37 161.0	1 00	48 931.7	383.8
21	8	1	650.35	.10	1	39 019.1	05	53 009.0	450.4
22	8	2	681.32	.10	2	40 877.2	10	57 086.2	522.4
23	8	3	712.28	.10	3	42 735.3	15	61 163.3	599.7
24	8	4	743.25	.11	4	44 593.4	20	65 240.2	682.3
64 25	30.969	25	774.22	1858.11	25	46 451.5	1 25	69 317.1	770.2
26	9	6	805.19	.12	6	48 309.6	30	73 393.9	863.5
27	9	7	836.16	.12	7	50 167.7	35	77 470.5	962.1
28	9	8	867.13	.13	8	52 025.8	40	81 546.9	1 066.1
29	9	9	898.10	.13	9	53 884.0	45	85 623.3	1 175.3
64 30	30.969	30	929.07	1858.13	30	55 742.1	1 50	89 699.5	1 289.9
31	9	1	960.04	.14	1	57 600.2	55	93 775.5	1 409.8
32	9	2	991.01	.14	2	59 458.4	2 00	97 851	1 535
33	9	3	1 021.97	.15	3	61 316.5	3 00	146 747	3 454
34	9	4	1 052.94	.15	4	63 174.7	4 00	195 607	6 139
64 35	30.969	35	1 083.91	1858.16	35	65 032.8	5 00	244 418	9 590
36	9	6	1 114.88	.16	6	66 891.0	6 00	293 169	13 807
37	9	7	1 145.85	.16	7	68 749.1	7 00	341 848	18 788
38	69	8	1 176.82	.17	8	70 607.3	8 00	390 443	24 532
39	70	9	1 207.79	.17	9	72 465.5	9 00	438 942	31 037
64 40	30.970	40	1 238.76	1858.18	40	74 323.6	10 00	487 333	38 302
41	0	1	1 269.73	.18	1	76 181.8	11 00	535 604	46 326
42	0	2	1 300.69	.19	2	78 040.0	12 00	583 743	55 106
43	0	3	1 331.66	.19	3	79 898.2	13 00	631 739	64 639
44	0	4	1 362.63	.19	4	81 756.4	14 00	679 579	74 925
64 45	30.970	45	1 393.60	1858.20	45	83 614.6	15 00	727 252	85 959
46	0	6	1 424.57	.20	6	85 472.8	16 00	774 745	97 741
47	0	7	1 455.54	.21	7	87 331.0	17 00	822 049	110 265
48	0	8	1 486.51	.21	8	89 189.2	18 00	869 150	123 530
49	0	9	1 517.48	.22	9	91 047.4	19 00	916 037	137 533
64 50	30.970	50	1 548.45	1858.22	50	92 905.6	20 00	962 698	152 269
51	0	1	1 579.41	.22	1	94 763.9	21 00	1 009 123	167 735
52	0	2	1 610.38	.23	2	96 622.1	22 00	1 055 300	183 927
53	1	3	1 641.35	.23	3	98 480.3	23 00	1 101 216	200 842
54	1	4	1 672.32	.24	4	100 338.6	24 00	1 146 862	218 475
64 55	30.971	55	1 703.29	1858.24	55	102 196.8	25 00	1 192 226	236 822
56	1	6	1 734.26	.25	6	104 055.0	26 00	1 237 296	255 879
57	1	7	1 765.23	.25	7	105 913.3	27 00	1 282 062	275 639
58	1	8	1 796.20	.25	8	107 771.5	28 00	1 326 512	296 100
59	1	9	1 827.17	.26	9	109 629.8	29 00	1 370 635	317 256
64 60	30.971	60	1 858.13	1858.26	60	111 488.1	30 00	1 414 422	339 100

Latitude 65° to 66°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
65 00	13.10	26.21	39.31	52.42	65.52	78.63	91.73	104.84	117.94	786.3	1572.6	2358.9	3145.2	3931.5
1	.10	.19	.29	.39	.48	.58	.68	.77	.87	5.8	1.6	7.4	3.2	29.0
2	.09	.18	.27	.35	.44	.53	.62	.71	.80	5.3	70.6	5.9	41.2	6.6
3	.08	.16	.24	.32	.40	.48	.56	.64	.72	4.8	69.7	4.5	39.3	4.1
4	.07	.14	.22	.29	.36	.43	.50	.58	.65	4.3	8.7	3.0	7.3	21.6
65 05	13.06	26.13	39.19	52.26	65.32	78.39	91.45	104.51	117.57	783.8	1567.7	2351.5	3135.4	3919.2
6	.06	.11	.17	.22	.28	.33	.39	.45	.50	3.3	6.7	50.0	3.4	6.7
7	.05	.10	.14	.19	.24	.29	.33	.38	.43	2.9	5.7	48.6	31.4	4.3
8	.04	.08	.12	.16	.20	.24	.28	.31	.35	2.4	4.8	7.1	29.5	11.8
9	.03	.06	.09	.13	.16	.19	.22	.25	.28	1.9	3.8	5.6	7.5	09.4
65 10	13.02	26.05	39.07	52.09	65.12	78.14	91.16	104.18	117.21	781.4	1562.8	2344.2	3125.6	3906.9
11	.01	.03	.05	.06	.07	.09	.10	.12	.13	0.9	1.8	2.7	3.6	4.5
12	.01	.01	.02	2.03	5.03	8.04	1.05	4.05	7.06	80.4	60.8	41.2	21.6	902.0
13	3.00	6.00	9.00	1.99	4.99	7.99	0.99	3.99	6.99	79.9	59.9	39.7	19.7	899.6
14	2.99	5.98	8.97	.96	.95	.94	.93	.92	.91	9.4	8.9	8.3	7.7	7.1
65 15	12.98	25.96	38.95	51.93	64.91	77.89	90.88	103.86	116.84	778.9	1557.9	2336.8	3115.7	3894.7
16	.97	.95	.92	.90	.87	.84	.82	.79	.77	8.4	6.9	5.3	3.8	92.2
17	.97	.93	.90	.86	.83	.80	.76	.73	.69	8.0	5.9	3.9	11.8	89.8
18	.96	.92	.87	.83	.79	.75	.70	.66	.62	7.5	5.0	2.4	09.8	7.3
19	.95	.90	.85	.80	.75	.70	.65	.60	.55	7.0	4.0	30.9	7.9	4.9
65 20	12.94	25.88	38.82	51.77	64.71	77.65	90.59	103.53	116.47	776.5	1553.0	2329.4	3105.9	3882.4
21	.93	.87	.80	.73	.67	.60	.53	.46	.40	6.0	2.0	8.0	4.0	79.9
22	.92	.85	.77	.70	.63	.55	.48	.40	.32	5.5	1.0	6.5	2.0	7.5
23	.92	.83	.75	.67	.58	.50	.42	.33	.25	5.0	50.0	5.0	100.0	5.0
24	.91	.82	.73	.63	.54	.45	.36	.27	.18	4.5	49.0	3.5	098.1	2.6
65 25	12.90	25.80	38.70	51.60	64.50	77.40	90.30	103.21	116.10	774.0	1548.0	2322.1	3096.1	3870.1
26	.89	.78	.68	.57	.46	.35	.24	.14	6.03	3.5	7.0	20.6	4.1	67.6
27	.88	.77	.65	.54	.42	.30	.19	.07	5.96	3.0	6.0	19.1	2.2	5.2
28	.88	.75	.63	.50	.38	.25	.13	3.01	.88	2.5	5.1	7.6	90.2	2.7
29	.87	.74	.60	.47	.34	.21	.07	2.94	.81	2.1	4.1	6.2	88.2	60.3
65 30	12.86	25.72	38.58	51.44	64.30	77.16	90.02	102.88	115.73	771.6	1543.1	2314.7	3086.3	3857.8
31	.85	.70	.55	.41	.26	.11	89.96	.81	.66	1.1	2.1	3.2	4.3	5.4
32	.84	.69	.53	.37	.22	.06	.90	.75	.58	0.6	1.1	1.7	2.3	2.9
33	.83	.67	.50	.34	.17	7.01	.84	.68	.51	70.1	40.2	10.3	80.3	50.4
34	.83	.65	.48	.31	.13	6.96	.79	.61	.44	69.6	39.2	08.8	78.4	48.0
65 35	12.82	25.64	38.46	51.27	64.09	76.91	89.73	102.55	115.36	769.1	1538.2	2307.3	3076.4	3845.5
36	.81	.62	.43	.24	.05	.86	.67	.48	.29	8.6	7.2	5.8	4.4	3.1
37	.80	.60	.41	.21	4.01	.81	.61	.42	.22	8.1	6.2	4.4	2.5	40.6
38	.79	.59	.38	.17	3.97	.76	.56	.35	.14	7.6	5.3	2.9	70.5	38.1
39	.79	.57	.36	.14	.93	.71	.50	.29	.07	7.1	4.3	301.4	68.5	5.7
65 40	12.78	25.55	38.33	51.11	63.89	76.66	89.44	102.22	115.00	766.6	1533.3	2299.9	3066.6	3833.2
41	.77	.54	.31	.08	.85	.61	.38	.15	4.92	6.1	2.3	8.4	4.6	30.7
42	.76	.52	.28	.04	.81	.57	.33	.09	.85	5.7	1.3	7.0	2.6	28.3
43	.75	.51	.26	1.01	.76	.52	.27	2.02	.77	5.2	30.4	5.5	60.7	5.8
44	.74	.49	.23	0.98	.72	.47	.21	1.95	.70	4.7	29.4	4.0	58.7	3.3
65 45	12.74	25.47	38.21	50.95	63.68	76.42	89.15	101.89	114.63	764.2	1528.4	2292.5	3056.7	3820.9
46	.73	.46	.18	.91	.64	.37	.10	.82	.55	3.7	7.4	91.0	4.7	18.4
47	.72	.44	.16	.88	.60	.32	9.04	.76	.48	3.2	6.4	89.6	2.8	6.0
48	.71	.42	.14	.85	.56	.27	8.98	.69	.41	2.7	5.4	8.1	50.8	3.5
49	.70	.41	.11	.81	.52	.22	.92	.63	.33	2.2	4.4	6.6	48.8	11.0
65 50	12.70	25.39	38.09	50.78	63.48	76.17	88.87	101.56	114.26	761.7	1523.4	2285.1	3046.9	3808.6
51	.69	.37	.06	.75	.44	.12	.81	.50	.18	1.2	2.4	3.7	4.9	6.1
52	.68	.36	.04	.71	.39	.07	.75	.43	.11	0.7	1.4	2.2	2.9	3.6
53	.67	.34	8.01	.68	.35	6.02	.69	.37	4.04	60.2	20.5	80.7	40.9	801.2
54	.66	.32	7.99	.65	.31	5.97	.64	.30	3.96	59.7	19.5	79.2	39.0	798.7
65 55	12.65	25.31	37.96	50.62	63.27	75.92	88.58	101.23	113.89	759.2	1518.5	2277.7	3037.0	3796.2
56	.65	.29	.94	.58	.23	.88	.52	.17	.81	8.8	7.5	6.3	5.0	3.8
57	.64	.28	.91	.55	.19	.83	.46	.10	.74	8.3	6.5	4.8	3.0	91.3
58	.63	.26	.89	.52	.15	.78	.41	1.03	.66	7.8	5.6	3.3	31.1	88.8
59	.62	.24	.86	.48	.10	.73	.35	0.97	.59	7.3	4.6	1.8	29.1	6.3
65 60	12.61	25.23	37.84	50.45	63.06	75.68	88.29	100.90	113.52	756.8	1513.6	2270.3	3027.1	3783.9

Lat.		Latitude 65° to 66°—Meridional arcs.						Latitude 65°—Co-ordinates of curvature.		
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
65	00	30.971			1858.26					
	1	1	1	30.97	.27	1	1 858.3	0 1	786.3	0.1
	2	1	2	61.95	.27	2	3 716.5	2	1 572.6	0.4
	3	1	3	92.92	.27	3	5 574.8	3	2 358.9	0.9
	4	1	4	123.89	.28	4	7 433.1	4	3 145.2	1.7
65	05	30.971	5	154.87	1858.28	5	9 291.4	0 5	3 931.5	2.6
	6	1	6	185.84	.29	6	11 149.7	6	4 717.8	3.7
	7	2	7	216.81	.29	7	13 007.9	7	5 504.0	5.1
	8	2	8	247.79	.30	8	14 866.2	8	6 290.3	6.6
	9	2	9	278.76	.30	9	16 724.5	9	7 076.5	8.4
65	10	30.972	10	309.73	1858.30	10	18 582.8	0 10	7 862.9	10.4
	11	2	1	340.70	.31	1	20 441.1	15	11 794.3	23.3
	12	2	2	371.68	.31	2	22 299.5	20	15 725.8	41.5
	13	2	3	402.65	.32	3	24 157.8	25	19 657.1	64.8
	14	2	4	433.62	.32	4	26 016.1	30	23 588.5	93.3
65	15	30.972	15	464.60	1858.33	15	27 874.4	0 35	27 519.8	127.0
	16	2	6	495.57	.33	6	29 732.7	40	31 451.1	165.8
	17	2	7	526.54	.33	7	31 591.1	45	35 382.3	209.9
	18	2	8	557.52	.34	8	33 449.4	50	39 313.4	259.1
	19	2	9	588.49	.34	9	35 307.7	55	43 244.5	313.5
65	20	30.972	20	619.46	1858.35	20	37 166.1	1 00	47 175.5	373.1
	21	2	1	650.44	.35	1	39 024.4	05	51 106.5	437.9
	22	3	2	681.41	.35	2	40 882.8	10	55 037.3	507.8
	23	3	3	712.38	.36	3	42 741.2	15	58 968.0	583.0
	24	3	4	743.36	.36	4	44 599.5	20	62 898.7	663.3
65	25	30.973	25	774.33	1858.37	25	46 457.9	1 25	66 829.2	748.8
	26	3	6	805.30	.37	6	48 316.2	30	70 759.6	839.5
	27	3	7	836.27	.38	7	50 174.6	35	74 689.9	935.4
	28	3	8	867.25	.38	8	52 033.0	40	78 620.1	1 036.4
	29	3	9	898.22	.38	9	53 891.4	45	82 550.1	1 142.6
65	30	30.973	30	929.19	1858.39	30	55 749.8	1 50	86 479.9	1 254.0
	31	3	1	960.17	.39	1	57 608.2	55	90 409.7	1 370.6
	32	3	2	991.14	.40	2	59 466.5	2 00	94 339	1 492
	33	3	3	1 022.11	.40	3	61 324.9	3 00	141 479	3 358
	34	3	4	1 053.09	.40	4	63 183.3	4 00	188 584	5 968
65	35	30.973	35	1 084.06	1858.41	35	65 041.8	5 00	235 642	9 323
	36	4	6	1 115.03	.41	6	66 900.2	6 00	282 640	13 422
	37	4	7	1 146.01	.42	7	68 758.6	7 00	329 568	18 265
	38	4	8	1 176.98	.42	8	70 617.0	8 00	376 413	23 848
	39	4	9	1 207.95	.43	9	72 475.4	9 00	423 165	30 172
65	40	30.974	40	1 238.93	1858.43	40	74 333.9	10 00	469 810	37 235
	41	4	1	1 269.90	.43	1	76 192.3	11 00	516 338	45 035
	42	4	2	1 300.87	.44	2	78 050.7	12 00	562 736	53 569
	43	4	3	1 331.84	.44	3	79 909.2	13 00	608 994	62 837
	44	4	4	1 362.82	.45	4	81 767.6	14 00	655 100	72 835
65	45	30.974	45	1 393.79	1858.45	45	83 626.1	15 00	701 041	83 561
	46	4	6	1 424.76	.45	6	85 484.5	16 00	746 807	95 012
	47	4	7	1 455.74	.46	7	87 343.0	17 00	792 387	107 186
	48	4	8	1 486.71	.46	8	89 201.4	18 00	837 768	120 079
	49	4	9	1 517.68	.47	9	91 059.9	19 00	882 939	133 688
65	50	30.975	50	1 548.66	1858.47	50	92 918.4	20 00	927 889	148 011
	51	5	1	1 579.63	.47	1	94 776.8	21 00	972 608	163 042
	52	5	2	1 610.60	.48	2	96 635.3	22 00	1 017 082	178 779
	53	5	3	1 641.58	.48	3	98 493.8	23 00	1 061 303	195 217
	54	5	4	1 672.55	.49	4	100 352.3	24 00	1 105 258	212 353
65	55	30.975	55	1 703.52	1858.49	55	102 210.8	25 00	1 148 936	230 182
	56	5	6	1 734.50	.50	6	104 069.3	26 00	1 192 327	248 699
	57	5	7	1 765.47	.50	7	105 927.8	27 00	1 235 420	267 901
	58	5	8	1 796.44	.50	8	107 786.3	28 00	1 278 203	287 782
	59	5	9	1 827.41	.51	9	109 644.8	29 00	1 320 667	308 337
65	60	30.975	60	1 858.39	1858.51	60	111 503.3	30 00	1 362 800	329 560

Latitude 66° to 67°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
66 00	12.61	25.23	37.84	50.45	63.06	75.68	88.29	100.90	113.52	756.8	1513.6	2270.3	3027.1	3783.9
1	.60	.21	.81	.42	3.02	.63	.23	.84	.44	6.3	2.6	68.8	5.1	81.4
2	.60	.19	.79	.39	2.98	.58	.17	.77	.37	5.8	1.6	7.4	3.2	78.9
3	.59	.18	.77	.35	.94	.53	.12	.71	.29	5.3	10.6	5.9	21.2	6.5
4	.58	.16	.74	.32	.90	.48	.06	.64	.22	4.8	09.6	4.4	19.2	4.0
66 05	12.57	25.14	37.72	50.29	62.86	75.43	88.00	100.57	113.15	754.3	1508.6	2262.9	3017.2	3771.5
6	.56	.13	.69	.25	.82	.38	7.95	.51	.07	3.8	7.6	1.4	5.2	69.1
7	.56	.11	.67	.22	.78	.33	.89	.44	3.00	3.3	6.6	60.0	3.3	6.6
8	.55	.09	.64	.19	.73	.28	.83	.38	2.92	2.8	5.7	58.5	11.3	4.1
9	.54	.08	.62	.15	.69	.23	.77	.31	.85	2.3	4.7	7.0	09.3	61.6
66 10	12.53	25.06	37.59	50.12	62.65	75.18	87.71	100.25	112.78	751.8	1503.7	2255.5	3007.3	3759.2
11	.52	.04	.57	.09	.61	.13	.66	.18	.70	1.3	2.7	4.0	5.4	6.7
12	.51	.03	.54	.06	.57	.08	.60	.11	.63	0.8	1.7	2.5	3.4	4.2
13	.51	.01	.52	50.02	.53	5.04	.54	100.05	.55	50.4	500.7	51.1	3001.4	51.8
14	.50	5.00	.49	49.99	.49	4.99	.48	99.98	.48	49.9	499.7	49.6	2999.4	49.3
66 15	12.49	24.98	37.47	49.96	62.45	74.94	87.43	99.91	112.40	749.4	1498.7	2248.1	2997.4	3746.8
16	.48	.96	.44	.92	.40	.89	.37	.85	.33	8.9	7.7	6.6	5.5	4.3
17	.47	.95	.42	.89	.36	.84	.31	.78	.26	8.4	6.7	5.1	3.5	41.9
18	.46	.93	.39	.86	.32	.79	.25	.72	.18	7.9	5.8	3.6	91.5	39.4
19	.46	.91	.37	.83	.28	.74	.19	.65	.11	7.4	4.8	2.1	89.5	6.9
66 20	12.45	24.90	37.34	49.79	62.24	74.69	87.14	99.58	112.03	746.9	1493.8	2240.7	2987.5	3734.4
21	.44	.88	.32	.76	.20	.64	.08	.52	1.96	6.4	2.8	39.2	5.6	32.0
22	.43	.86	.29	.73	.16	.59	7.02	.45	.89	5.9	1.8	7.7	3.6	29.5
23	.42	.85	.27	.69	.12	.54	6.96	.39	.81	5.4	90.8	6.2	81.6	7.0
24	.42	.83	.24	.66	.08	.49	.91	.32	.73	4.9	89.8	4.7	79.6	4.5
66 25	12.41	24.81	37.22	49.63	62.03	74.44	86.85	99.25	111.66	744.4	1488.8	2233.2	2977.6	3722.0
26	.40	.80	.20	.59	1.99	.39	.79	.18	.59	3.9	87.8	1.7	5.7	19.6
27	.39	.78	.17	.56	.95	.34	.73	.12	.51	3.4	6.8	30.3	3.7	7.1
28	.38	.76	.15	.53	.91	.29	.67	9.05	.44	2.9	5.9	28.8	71.7	4.6
29	.37	.75	.12	.49	.87	.24	.62	8.99	.36	2.4	4.9	7.3	69.7	12.1
66 30	12.37	24.73	37.10	49.46	61.83	74.19	86.56	98.93	111.29	741.9	1483.9	2225.8	2967.7	3709.7
31	.36	.71	.07	.43	.79	.14	.50	.86	.22	1.4	2.9	4.3	5.7	7.2
32	.35	.70	.05	.40	.75	.09	.44	.79	.14	0.9	1.9	2.8	3.8	4.7
33	.34	.68	.02	.36	.70	4.04	.38	.73	1.07	40.4	80.9	21.3	61.8	702.2
34	.33	.66	7.00	.33	.66	3.99	.33	.66	0.99	39.9	79.9	19.8	59.8	699.7
66 35	12.32	24.65	36.97	49.30	61.62	73.95	86.27	98.59	110.91	739.5	1478.9	2218.4	2957.8	3697.3
36	.32	.63	.95	.26	.58	.90	.21	.53	.84	9.0	7.9	6.9	5.8	4.8
37	.31	.62	.92	.23	.54	.85	.15	.46	.77	8.5	6.9	5.4	3.8	92.3
38	.30	.60	.90	.20	.50	.80	.10	.39	.69	8.0	5.9	3.9	51.9	89.8
39	.29	.58	.87	.16	.45	.75	6.04	.33	.62	7.5	4.9	2.4	49.9	7.3
66 40	12.28	24.57	36.85	49.13	61.41	73.70	85.98	98.26	110.55	737.0	1473.9	2210.9	2947.9	3684.9
41	.27	.55	.82	.10	.37	.65	.92	.20	.47	6.5	2.9	09.4	5.9	82.4
42	.27	.53	.80	.07	.33	.60	.86	.13	.40	6.0	1.9	7.9	3.9	79.9
43	.26	.52	.77	.03	.29	.55	.81	.06	.32	5.5	1.0	6.4	41.9	7.4
44	.25	.50	.75	9.00	.25	.50	.75	8.00	.25	5.0	70.0	4.9	39.9	4.9
66 45	12.24	24.48	36.72	48.97	61.21	73.45	85.69	97.93	110.17	734.5	1469.0	2203.5	2937.9	3672.4
46	.23	.47	.70	.93	.17	.40	.63	.87	.10	4.0	8.0	2.0	6.0	70.0
47	.22	.45	.68	.90	.12	.35	.57	.80	10.03	3.5	7.0	200.5	4.0	67.5
48	.22	.44	.65	.87	.09	.30	.52	.74	09.96	3.0	6.0	199.0	2.0	5.0
49	.21	.42	.63	.83	.04	.25	.46	.67	.88	2.5	5.0	7.5	30.0	2.5
66 50	12.20	24.40	36.60	48.80	61.00	73.20	85.40	97.60	109.80	732.0	1464.0	2196.0	2928.0	3660.0
51	.19	.38	.58	.77	0.96	.15	.34	.53	.73	1.5	3.0	4.5	6.0	57.5
52	.18	.37	.55	.73	.92	.10	.28	.47	.65	1.0	2.0	3.0	4.0	5.0
53	.18	.35	.53	.70	.88	.05	.23	.40	.58	0.5	1.0	1.5	2.0	2.6
54	.17	.33	.50	.67	.84	3.00	.17	.34	.50	30.0	60.0	90.0	20.1	50.1
66 55	12.16	24.32	36.48	48.63	60.79	72.95	85.11	97.27	109.44	729.5	1459.0	2188.5	2918.1	3647.6
56	.15	.30	.45	.60	.75	.90	5.05	.20	.35	9.0	8.0	7.1	6.1	5.1
57	.14	.28	.43	.57	.71	.85	4.99	.14	.28	8.5	7.0	5.6	4.1	2.6
58	.13	.27	.40	.53	.67	.80	.94	.07	.20	8.0	6.1	4.1	2.1	40.1
59	.13	.25	.38	.50	.63	.75	.88	7.00	.13	7.5	5.1	2.6	10.1	37.6
66 60	12.12	24.23	36.35	48.47	60.59	72.70	84.82	96.94	109.05	727.0	1454.1	2181.1	2908.1	3635.1

Lat.	Latitude 66° to 67°—Meridional arcs.						Latitude 66°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
66 00	30.975			1858.51					
1	5	1	30.98	.52	1	1 858.5	0 1	756.8	0.1
2	5	2	61.95	.52	2	3 717.0	2	1 513.6	0.4
3	5	3	92.93	.52	3	5 575.6	3	2 270.3	0.9
4	5	4	123.91	.53	4	7 434.1	4	3 027.1	1.6
66 05	30.976	5	154.89	1858.53	5	9 292.6	0 5	3 783.9	2.5
6	6	6	185.86	.54	6	11 151.1	6	4 540.7	3.6
7	6	7	216.84	.54	7	13 009.7	7	5 297.5	4.9
8	6	8	247.82	.54	8	14 868.2	8	6 054.2	6.4
9	6	9	278.80	.55	9	16 726.8	9	6 811.0	8.1
66 10	30.976	10	309.77	1858.55	10	18 585.3	0 10	7 567.8	10.1
11	6	1	340.75	.56	1	20 443.9	15	11 351.7	22.6
12	6	2	371.73	.56	2	22 302.4	20	15 135.5	40.2
13	6	3	402.70	.56	3	24 161.0	25	18 919.3	62.8
14	6	4	433.68	.57	4	26 019.6	30	22 703.1	90.5
66 15	30.976	15	464.66	1858.57	15	27 878.2	0 35	26 486.8	123.2
16	6	6	495.64	.58	6	29 736.7	40	30 270.5	160.9
17	6	7	526.61	.58	7	31 595.3	45	34 054.2	203.6
18	6	8	557.59	.59	8	33 453.9	50	37 837.8	251.4
19	6	9	588.57	.59	9	35 312.5	55	41 621.3	304.2
66 20	30.977	20	619.54	1858.59	20	37 171.1	1 00	45 404.8	362.0
21	7	1	650.52	.60	1	39 029.7	05	49 188.1	424.8
22	7	2	681.50	.60	2	40 888.3	10	52 971.4	492.7
23	7	3	712.48	.61	3	42 746.9	15	56 754.5	565.6
24	7	4	743.45	.61	4	44 605.5	20	60 537.6	643.5
66 25	30.977	25	774.43	1858.61	25	46 464.1	1 25	64 320.6	726.5
26	7	6	805.41	.62	6	48 322.7	30	68 103.5	814.4
27	7	7	836.39	.62	7	50 181.3	35	71 886.2	907.4
28	7	8	867.36	.63	8	52 040.0	40	75 668.8	1 005.4
29	7	9	898.34	.63	9	53 898.6	45	79 451.3	1 108.5
66 30	30.977	30	929.32	1858.63	30	55 757.2	1 50	83 233.7	1 216.6
31	7	1	960.29	.64	1	57 615.8	55	87 015.8	1 329.7
32	7	2	991.27	.64	2	59 474.5	2 00	90 798	1 448
33	7	3	1 022.25	.65	3	61 333.1	3 00	136 168	3 257
34	8	4	1 053.23	.65	4	63 191.8	4 00	181 504	5 790
66 35	30.978	35	1 084.20	1858.65	35	65 050.4	5 00	226 793	9 045
36	8	6	1 115.18	.66	6	66 909.1	6 00	272 024	13 022
37	8	7	1 146.16	.66	7	68 767.7	7 00	317 187	17 719
38	8	8	1 177.13	.67	8	70 626.4	8 00	362 269	23 136
39	8	9	1 208.11	.67	9	72 485.1	9 00	407 259	29 271
66 40	30.978	40	1 239.09	1858.67	40	74 343.8	10 00	452 145	36 122
41	8	1	1 270.07	.68	1	76 202.4	11 00	496 916	43 689
42	8	2	1 301.04	.68	2	78 061.1	12 00	541 561	51 968
43	8	3	1 332.02	.69	3	79 919.8	13 00	586 069	60 958
44	8	4	1 363.00	.69	4	81 778.5	14 00	630 427	70 656
66 45	30.978	45	1 393.98	1858.69	45	83 637.2	15 00	674 625	81 060
46	8	6	1 424.95	.70	6	85 495.9	16 00	718 652	92 168
47	8	7	1 455.93	.70	7	87 354.6	17 00	762 495	103 976
48	8	8	1 486.91	.71	8	89 213.3	18 00	806 145	116 482
49	9	9	1 517.88	.71	9	91 072.0	19 00	849 590	129 682
66 50	30.979	50	1 548.86	1858.71	50	92 930.7	20 00	892 820	143 573
51	9	1	1 579.84	.72	1	94 789.4	21 00	935 822	158 152
52	9	2	1 610.82	.72	2	96 648.1	22 00	978 586	173 414
53	9	3	1 641.79	.73	3	98 506.9	23 00	1 021 101	189 356
54	9	4	1 672.77	.73	4	100 365.6	24 00	1 063 357	205 974
66 55	30.979	55	1 703.75	1858.73	55	102 224.3	25 00	1 105 343	223 264
56	9	6	1 734.73	.74	6	104 083.0	26 00	1 147 048	241 221
57	9	7	1 765.70	.74	7	105 941.8	27 00	1 188 461	259 840
58	9	8	1 796.68	.75	8	107 800.5	28 00	1 229 571	279 118
59	9	9	1 827.66	.75	9	109 659.3	29 00	1 270 370	299 049
66 60	30.979	60	1 858.63	1858.75	60	111 518.0	30 00	1 310 845	319 627

Latitude 67° to 68°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
67 00	12.12	24.23	36.35	48.47	60.59	72.70	84.82	96.94	109.05	727.0	1454.0	2181.1	2908.1	3635.1
1	.11	.22	.33	.44	.55	.65	.76	.87	8.98	6.5	3.1	79.6	6.1	2.7
2	.10	.20	.30	.40	.50	.60	.70	.81	.91	6.0	2.1	8.1	4.1	30.2
3	.09	.18	.28	.37	.46	.55	.65	.74	.83	5.5	1.1	6.6	2.1	27.7
4	.08	.17	.25	.34	.42	.50	.59	.67	.76	5.0	50.1	5.1	900.1	5.2
67 05	12.08	24.15	36.23	48.30	60.38	72.45	84.53	96.61	108.68	724.5	1449.1	2173.6	2898.2	3622.7
6	.07	.13	.20	.27	.34	.40	.47	.54	.61	4.0	8.1	2.1	6.2	20.2
7	.06	.12	.18	.24	.30	.35	.41	.47	.53	3.5	7.1	70.6	4.2	17.7
8	.05	.10	.15	.20	.25	.30	.35	.41	.46	3.0	6.1	69.1	2.2	5.2
9	.04	.08	.13	.17	.21	.25	.30	.34	.38	2.5	5.1	7.6	90.2	2.7
67 10	12.03	24.07	36.10	48.14	60.17	72.20	84.24	96.27	108.31	722.0	1444.1	2166.1	2888.2	3610.2
11	.03	.05	.08	.10	.13	.15	.18	.21	.23	1.5	3.1	4.6	6.2	07.7
12	.02	.04	.05	.07	.09	.11	.12	.14	.16	1.1	2.1	3.2	4.2	5.3
13	.01	.02	.03	.04	.05	.06	.07	.07	.08	0.6	1.1	1.7	2.2	2.8
14	2.00	4.00	6.00	8.00	60.01	2.01	4.01	6.01	8.01	20.1	40.1	60.2	80.2	3600.3
67 15	11.99	23.99	35.98	47.97	59.96	71.96	83.95	95.94	107.93	719.6	1439.1	2158.7	2878.2	3597.8
16	.98	.97	.95	.94	.92	.91	.89	.87	.86	9.1	8.1	7.2	6.2	5.3
17	.98	.95	.93	.90	.88	.86	.83	.81	.78	8.6	7.1	5.7	4.2	2.8
18	.97	.94	.90	.87	.84	.81	.77	.74	.71	8.1	6.1	4.2	2.2	90.3
19	.96	.92	.88	.84	.80	.76	.72	.68	.64	7.6	5.1	2.7	70.2	87.8
67 20	11.95	23.90	35.85	47.80	59.76	71.71	83.66	95.61	107.56	717.1	1434.1	2151.2	2868.3	3585.3
21	.94	.89	.83	.77	.72	.66	.60	.54	.48	6.6	3.1	49.7	6.3	2.8
22	.93	.87	.80	.74	.67	.61	.54	.48	.41	6.1	2.1	8.2	4.3	80.3
23	.93	.85	.78	.70	.63	.56	.49	.41	.33	5.6	1.1	6.7	2.3	77.8
24	.92	.84	.75	.67	.59	.51	.42	.34	.26	5.1	30.1	5.2	60.3	5.3
67 25	11.91	23.82	35.73	47.64	59.55	71.46	83.37	95.28	107.18	714.6	1429.1	2143.7	2858.3	3572.8
26	.90	.80	.70	.60	.51	.41	.31	.21	.11	4.1	8.1	2.2	6.3	70.3
27	.89	.79	.68	.57	.46	.36	.25	.14	7.03	3.6	7.1	40.7	4.3	67.8
28	.88	.77	.65	.54	.42	.31	.19	.07	6.96	3.1	6.1	39.2	2.3	5.3
29	.88	.75	.63	.50	.38	.26	.13	5.01	.88	2.6	5.1	7.7	50.3	2.8
67 30	11.87	23.74	35.60	47.47	59.34	71.21	83.07	94.94	106.81	712.1	1424.1	2136.2	2848.3	3560.3
31	.86	.72	.58	.44	.30	.16	3.02	.88	.73	1.6	3.1	4.7	6.3	57.8
32	.85	.70	.55	.40	.26	.11	2.96	.81	.66	1.1	2.1	3.2	4.3	5.3
33	.84	.69	.53	.37	.21	.06	.90	.74	.58	0.6	1.1	1.7	2.3	2.8
34	.83	.67	.50	.34	.17	1.01	.84	.68	.51	10.1	20.1	30.2	40.3	50.3
67 35	11.83	23.65	35.48	47.30	59.13	70.96	82.78	94.61	106.43	709.6	1419.1	2128.7	2838.3	3547.8
36	.82	.64	.45	.27	.09	.91	.72	.54	.36	9.1	8.1	7.2	6.3	5.3
37	.81	.62	.43	.24	.05	.86	.66	.48	.28	8.6	7.1	5.7	4.3	2.8
38	.80	.60	.40	.20	9.00	.81	.61	.41	.21	8.1	6.1	4.2	2.3	40.3
39	.79	.59	.38	.17	8.96	.76	.55	.34	.13	7.6	5.1	2.7	30.3	37.8
67 40	11.78	23.57	35.35	47.14	58.92	70.71	82.49	94.28	106.06	707.1	1414.1	2121.2	2828.3	3535.3
41	.78	.55	.33	.10	.88	.66	.43	.21	5.98	6.6	3.1	19.7	6.3	2.8
42	.77	.54	.30	.07	.84	.61	.37	.14	.91	6.1	2.1	8.2	4.3	30.3
43	.76	.52	.28	.04	.80	.56	.32	.08	.83	5.6	1.1	6.7	2.3	27.8
44	.75	.50	.25	47.00	.76	.51	.26	4.01	.76	5.1	10.1	5.2	20.3	5.3
67 45	11.74	23.49	35.23	46.97	58.71	70.46	82.20	93.94	105.68	704.6	1409.1	2113.7	2818.3	3522.8
46	.73	.47	.20	.94	.67	.41	.14	.88	.61	4.1	8.1	2.2	6.3	20.3
47	.73	.45	.18	.90	.63	.36	.08	.81	.53	3.6	7.1	10.7	4.3	17.8
48	.72	.44	.15	.87	.59	.31	2.02	.74	.46	3.1	6.1	09.2	2.3	5.3
49	.71	.42	.13	.84	.55	.26	1.97	.68	.38	2.6	5.1	7.7	10.3	2.8
67 50	11.70	23.40	35.10	46.80	58.51	70.21	81.91	93.61	105.31	702.1	1404.1	2106.2	2808.3	3510.3
51	.69	.39	.08	.77	.46	.16	.85	.54	.23	1.6	3.1	4.7	6.3	07.8
52	.68	.37	.05	.74	.42	.11	.79	.47	.16	1.1	2.1	3.2	4.3	5.3
53	.68	.35	.03	.70	.38	.06	.73	.41	.08	0.6	1.1	1.7	2.2	2.8
54	.67	.34	5.00	.67	.34	70.01	.67	.34	5.01	700.1	400.1	100.2	800.2	500.3
67 55	11.66	23.32	34.98	46.64	58.30	69.96	81.62	93.28	104.93	699.6	1399.1	2098.7	2798.2	3497.8
56	.65	.30	.95	.60	.26	.91	.56	.21	.86	9.1	8.1	7.2	6.2	5.3
57	.64	.29	.93	.57	.21	.86	.50	.14	.78	8.6	7.1	5.7	4.2	2.8
58	.63	.27	.90	.54	.17	.81	.44	.07	.71	8.1	6.1	4.2	2.2	90.3
59	.63	.26	.88	.50	.13	.76	.38	3.01	.64	7.6	5.1	2.7	90.2	87.8
67 60	11.62	23.24	34.85	46.47	58.09	69.71	81.32	92.94	104.56	697.1	1394.1	2091.2	2788.2	3485.3

Lat.		Latitude 67° to 68°—Meridional arcs.						Latitude 67°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
67	00	30.979			1858.75						
	1	9	1	30.98	.76	1	1 858.8	0	1	727.1	0.1
	2	9	2	61.96	.76	2	3 717.5		2	1 454.1	0.4
	3	79	3	92.94	.77	3	5 576.3		3	2 181.1	0.9
	4	80	4	123.92	.77	4	7 435.0		4	2 908.1	1.6
67	05	30.980	5	154.91	1858.77	5	9 293.8	0	5	3 635.1	2.4
	6	0	6	185.89	.78	6	11 152.6		6	4 362.2	3.5
	7	0	7	216.87	.78	7	13 011.4		7	5 089.2	4.8
	8	0	8	247.85	.79	8	14 870.2		8	5 816.2	6.2
	9	0	9	278.83	.79	9	16 728.9		9	6 543.3	7.9
67	10	30.980	10	309.81	1858.79	10	18 587.7	0	10	7 270.3	9.7
	11	0	1	340.79	.80	1	20 446.5		15	10 905.4	21.9
	12	0	2	371.77	.80	2	22 305.3		20	14 540.5	38.9
	13	0	3	402.76	.81	3	24 164.1		25	18 175.6	60.8
	14	0	4	433.74	.81	4	26 022.9		30	21 810.6	87.6
67	15	30.980	15	464.72	1858.81	15	27 881.8	0	35	25 445.6	119.2
	16	0	6	495.70	.82	6	29 740.6		40	29 080.6	155.7
	17	0	7	526.68	.82	7	31 599.4		45	32 715.5	197.1
	18	0	8	557.66	.83	8	33 458.2		50	36 350.4	243.3
	19	0	9	588.64	.83	9	35 317.0		55	39 985.2	294.4
67	20	30.981	20	619.62	1858.83	20	37 175.9	1	00	43 619.9	350.4
	21	1	1	650.61	.84	1	39 034.7		05	47 254.5	411.2
	22	1	2	681.59	.84	2	40 893.6		10	50 889.1	476.9
	23	1	3	712.57	.84	3	42 752.4		15	54 523.5	547.5
	24	1	4	743.55	.85	4	44 611.2		20	58 157.9	622.9
67	25	30.981	25	774.53	1858.85	25	46 470.1	1	25	61 792.1	703.2
	26	1	6	805.51	.86	6	48 329.0		30	65 426.3	788.4
	27	1	7	836.49	.86	7	50 187.8		35	69 060.3	878.4
	28	1	8	867.47	.86	8	52 046.7		40	72 694.2	973.3
	29	1	9	898.46	.87	9	53 905.5		45	76 328.0	1 073.0
67	30	30.981	30	929.44	1858.87	30	55 764.4	1	50	79 961.6	1 177.4
	31	1	1	960.42	.88	1	57 623.3		55	83 595.1	1 287.1
	32	1	2	991.40	.88	2	59 482.2	2	00	87 228	1 401
	33	1	3	1 022.38	.88	3	61 341.0	3	00	130 815	3 153
	34	1	4	1 053.36	.89	4	63 199.9	4	00	174 367	5 605
67	35	30.982	35	1 084.34	1858.89	35	65 058.8	5	00	217 874	8 756
	36	2	6	1 115.32	.90	6	66 917.7	6	00	261 325	12 605
	37	2	7	1 146.30	.90	7	68 776.6	7	00	304 709	17 152
	38	2	8	1 177.29	.90	8	70 635.5	8	00	348 014	22 395
	39	2	9	1 208.27	.91	9	72 494.4	9	00	391 229	28 334
67	40	30.982	40	1 239.25	1858.91	40	74 353.3	10	00	434 343	34 966
	41	2	1	1 270.23	.92	1	76 212.2	11	00	477 345	42 289
	42	2	2	1 301.21	.92	2	78 071.2	12	00	520 224	50 303
	43	2	3	1 332.19	.92	3	79 930.1	13	00	562 969	59 004
	44	2	4	1 363.17	.93	4	81 789.0	14	00	605 568	68 391
67	45	30.982	45	1 394.15	1858.93	45	83 647.9	15	00	648 011	78 461
	46	2	6	1 425.14	.93	6	85 506.9	16	00	690 287	89 212
	47	2	7	1 456.12	.94	7	87 365.8	17	00	732 384	100 640
	48	2	8	1 487.10	.94	8	89 224.7	18	00	774 293	112 744
	49	2	9	1 518.08	.95	9	91 083.7	19	00	816 002	125 519
67	50	30.982	50	1 549.06	1858.95	50	92 942.6	20	00	857 500	138 962
	51	3	1	1 580.04	.95	1	94 801.6	21	00	898 776	153 070
	52	3	2	1 611.02	.96	2	96 660.5	22	00	939 821	167 840
	53	3	3	1 642.00	.96	3	98 519.5	23	00	980 623	183 267
	54	3	4	1 672.99	.97	4	100 378.4	24	00	1 021 173	199 348
67	55	30.983	55	1 703.97	1858.97	55	102 237.4	25	00	1 061 458	216 078
	56	3	6	1 734.95	.97	6	104 096.4	26	00	1 101 470	233 453
	57	3	7	1 765.93	.98	7	105 955.4	27	00	1 141 197	251 468
	58	3	8	1 796.91	.98	8	107 814.3	28	00	1 180 629	270 120
	59	3	9	1 827.89	.98	9	109 673.3	29	00	1 219 757	289 402
67	60	30.983	60	1 858.87	1858.99	60	111 532.3	30	00	1 258 571	309 311

Latitude 68° to 69°—arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
68 00	11.62	23.24	34.85	46.47	58.09	69.71	81.32	92.94	104.56	697.1	1394.1	2091.2	2788.2	3485.3
1	.61	.22	.83	.44	.05	.66	.26	.87	.48	6.6	3.1	89.7	6.2	2.8
2	.60	.20	.80	.40	8.01	.61	.21	.81	.41	6.1	2.1	8.2	4.2	80.3
3	.59	.18	.78	.37	7.96	.55	.15	.74	.33	5.5	1.1	6.6	2.2	77.7
4	.58	.17	.75	.34	.92	.50	.09	.67	.26	5.0	90.1	5.1	80.2	5.2
68 05	11.58	23.15	34.73	46.30	57.88	69.45	81.03	92.61	104.18	694.5	1389.1	2083.6	2778.2	3472.7
6	.57	.13	.70	.27	.84	.40	0.97	.54	.11	4.0	8.1	2.1	6.2	70.2
7	.56	.12	.68	.24	.80	.35	.91	.47	4.03	3.5	7.1	80.6	4.2	67.7
8	.55	.10	.65	.20	.75	.30	.85	.41	3.96	3.0	6.1	79.1	2.2	5.2
9	.54	.08	.63	.17	.71	.25	.80	.34	.88	2.5	5.1	7.6	70.2	2.7
68 10	11.53	23.07	34.60	46.14	57.67	69.20	80.74	92.27	103.81	692.0	1384.1	2076.1	2768.2	3460.2
11	.53	.05	.58	.10	.63	.15	.68	.21	.73	1.5	3.1	4.6	6.1	57.7
12	.52	.03	.55	.07	.59	.10	.62	.14	.66	1.0	2.1	3.1	4.1	5.2
13	.51	.02	.53	.04	.54	.05	.56	.07	.58	0.5	1.1	1.6	2.1	2.7
14	.50	3.00	.50	6.00	.50	9.00	.50	2.00	.50	90.0	80.1	70.1	60.1	50.1
68 15	11.49	22.98	34.48	45.97	57.46	68.95	80.44	91.94	103.43	689.5	1379.1	2068.6	2758.1	3447.6
16	.48	.97	.45	.93	.42	.90	.39	.87	.35	9.0	8.1	7.1	6.1	5.1
17	.48	.95	.43	.90	.38	.85	.33	.80	.28	8.5	7.1	5.6	4.1	2.6
18	.47	.93	.40	.87	.33	.80	.27	.74	.20	8.0	6.0	4.1	2.1	40.1
19	.46	.92	.38	.83	.29	.75	.21	.67	.13	7.5	5.0	2.6	50.1	37.6
68 20	11.45	22.90	34.35	45.80	57.25	68.70	80.15	91.60	103.05	687.0	1374.0	2061.0	2748.1	3435.1
21	.44	.88	.33	.77	.21	.65	.09	.54	2.98	6.5	3.0	59.5	6.0	2.6
22	.43	.87	.30	.73	.17	.60	80.03	.47	.90	6.0	2.0	8.0	4.0	30.0
23	.43	.85	.28	.70	.12	.55	79.97	.40	.83	5.5	1.0	6.5	2.0	27.5
24	.42	.83	.25	.67	.08	.50	.92	.33	.75	5.0	70.0	5.0	40.0	5.0
68 25	11.41	22.82	34.23	45.63	57.04	68.45	79.86	91.27	102.68	684.5	1369.0	2053.5	2738.0	3422.5
26	.40	.80	.20	.60	7.00	.40	.80	.20	.60	4.0	8.0	2.0	6.0	20.0
27	.39	.78	.18	.57	6.96	.35	.74	.13	.53	3.5	7.0	50.5	4.0	17.5
28	.38	.77	.15	.53	.92	.30	.69	.07	.45	3.0	6.0	49.0	2.0	5.0
29	.37	.75	.12	.50	.87	.25	.62	1.00	.37	2.5	5.0	7.5	30.0	12.4
68 30	11.37	22.73	34.10	45.47	56.83	68.20	79.56	90.93	102.30	682.0	1364.0	2046.0	2727.9	3409.9
31	.36	.72	.07	.44	.79	.15	.51	.86	.22	1.5	3.0	4.4	5.9	7.4
32	.35	.70	.05	.40	.75	.10	.45	.80	.15	1.0	2.0	2.9	3.9	4.9
33	.34	.68	.02	.37	.71	.05	.39	.73	.07	0.5	60.9	41.4	21.9	402.4
34	.33	.67	4.00	.33	.66	8.00	.33	.66	2.00	80.0	59.9	39.9	19.9	399.9
68 35	11.32	22.65	33.97	45.30	56.62	67.95	79.27	90.59	101.92	679.5	1358.9	2038.4	2717.9	3397.3
36	.32	.63	.95	.26	.58	.90	.21	.53	.84	9.0	7.9	6.9	5.9	4.8
37	.31	.62	.92	.23	.54	.85	.15	.46	.77	8.5	6.9	5.4	3.8	92.3
38	.30	.60	.90	.20	.50	.80	.10	.39	.69	8.0	5.9	3.9	11.8	89.8
39	.29	.58	.87	.16	.45	.75	9.04	.33	.62	7.5	4.9	2.4	09.8	7.3
68 40	11.28	22.57	33.85	45.13	56.41	67.70	78.98	90.26	101.54	677.0	1353.9	2030.9	2707.8	3384.8
41	.27	.55	.82	.10	.37	.64	.92	.19	.47	6.4	2.9	29.3	5.8	82.2
42	.27	.53	.80	.06	.33	.59	.86	.13	.39	5.9	1.9	7.8	3.8	79.7
43	.26	.51	.77	.03	.29	.54	.80	90.06	.32	5.4	50.9	6.3	01.8	7.2
44	.25	.50	.75	5.00	.24	.49	.74	89.99	.24	4.9	49.9	4.8	699.7	4.7
68 45	11.24	22.48	33.72	44.96	56.20	67.44	78.68	89.93	101.17	674.4	1348.9	2023.3	2697.7	3372.2
46	.23	.46	.70	.93	.16	.39	.62	.86	.09	3.9	7.9	1.8	5.7	69.6
47	.22	.45	.67	.89	.12	.34	.57	.79	1.02	3.4	6.9	20.3	3.7	7.1
48	.22	.43	.65	.86	.07	.29	.51	.72	0.94	2.9	5.8	18.8	91.7	4.6
49	.21	.42	.62	.82	6.03	.24	.45	.66	.87	2.4	4.8	7.2	89.7	62.1
68 50	11.20	22.40	33.60	44.79	55.99	67.19	78.39	89.59	100.79	671.9	1343.8	2015.7	2687.6	3359.6
51	.19	.38	.57	.76	.95	.14	.33	.52	.71	1.4	2.8	4.2	5.6	7.0
52	.18	.36	.55	.73	.91	.09	.27	.45	.64	0.9	1.8	2.7	3.6	4.5
53	.17	.35	.52	.69	.87	7.04	.21	.39	.56	70.4	40.8	11.2	81.6	52.0
54	.16	.33	.50	.66	.82	6.99	.15	.32	.49	69.9	39.8	09.7	79.6	49.5
68 55	11.16	22.31	33.47	44.63	55.78	66.94	78.09	89.25	100.41	669.4	1338.8	2008.2	2677.6	3346.9
56	.15	.30	.44	.59	.74	.89	8.04	.18	.33	8.9	7.8	6.7	5.5	4.4
57	.14	.28	.42	.56	.70	.84	7.98	.12	.26	8.4	6.8	5.1	3.5	41.9
58	.13	.26	.39	.53	.66	.79	.92	9.05	.18	7.9	5.7	3.6	71.5	39.4
59	.12	.25	.37	.49	.61	.74	.86	8.98	.11	7.4	4.7	2.1	69.5	6.9
68 60	11.11	22.23	33.34	44.46	55.57	66.69	77.80	88.92	100.03	666.9	1333.7	2000.6	2667.5	3334.3

Lat.	Latitude 68° to 69°—Meridional arcs.						Latitude 68°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
68 00	30.983			1858.99					
1	3	1	30.99	.99	1	1 859.0	0 1	697.1	0.1
2	3	2	61.97	9.00	2	3 718.0	2	1 394.1	0.4
3	3	3	92.96	.00	3	5 577.0	3	2 091.1	0.8
4	3	4	123.94	.00	4	7 436.0	4	2 788.2	1.5
68 05	30.983	5	154.93	1859.01	5	9 295.0	0 5	3 485.2	2.3
6	4	6	185.91	.01	6	11 154.0	6	4 182.3	3.4
7	4	7	216.90	.02	7	13 013.0	7	4 879.4	4.6
8	4	8	247.88	.02	8	14 872.0	8	5 576.4	6.0
9	4	9	278.87	.02	9	16 731.1	9	6 273.5	7.6
68 10	30.984	10	309.85	1859.03	10	18 590.1	0 10	6 970.5	9.4
11	4	1	340.84	.03	1	20 449.1	15	10 455.8	21.1
12	4	2	371.82	.03	2	22 308.1	20	13 941.0	37.6
13	4	3	402.81	.04	3	24 167.2	25	17 426.3	58.7
14	4	4	433.79	.04	4	26 026.2	30	20 911.4	84.6
68 15	30.984	15	464.78	1859.05	15	27 885.3	0 35	24 396.6	115.1
16	4	6	495.76	.05	6	29 744.3	40	27 881.7	150.4
17	4	7	526.75	.05	7	31 603.4	45	31 366.7	190.3
18	4	8	557.73	.06	8	33 462.4	50	34 851.7	235.0
19	4	9	588.72	.06	9	35 321.5	55	38 336.6	284.3
68 20	30.984	20	619.70	1859.06	20	37 180.5	1 00	41 821.5	338.4
21	4	1	650.69	.07	1	39 039.6	05	45 306.3	397.1
22	5	2	681.67	.07	2	40 898.7	10	48 791.0	460.6
23	5	3	712.66	.08	3	42 757.8	15	52 275.6	528.7
24	5	4	743.64	.08	4	44 616.8	20	55 760.1	601.6
68 25	30.985	25	774.63	1859.08	25	46 475.9	1 25	59 244.5	679.1
26	5	6	805.61	.09	6	48 335.0	30	62 728.8	761.4
27	5	7	836.60	.09	7	50 194.1	35	66 213.0	848.3
28	5	8	867.58	.10	8	52 053.2	40	69 697.1	940.0
29	5	9	898.57	.10	9	53 912.3	45	73 181.0	1 036.3
68 30	30.985	30	929.55	1859.10	30	55 771.4	1 50	76 664.9	1 137.3
31	5	1	960.54	.11	1	57 630.5	55	80 148.5	1 243.1
32	5	2	991.52	.11	2	59 489.6	2 00	83 632	1 353
33	5	3	1 022.51	.11	3	61 348.7	3 00	125 421	3 045
34	5	4	1 053.49	.12	4	63 207.8	4 00	167 177	5 413
68 35	30.985	35	1 084.48	1859.12	35	65 066.9	5 00	208 889	8 455
36	5	6	1 115.46	.13	6	66 926.0	6 00	250 546	12 173
37	5	7	1 146.45	.13	7	68 785.2	7 00	292 138	16 563
38	6	8	1 177.43	.13	8	70 644.3	8 00	333 653	21 627
39	6	9	1 208.42	.14	9	72 503.5	9 00	375 081	27 362
68 40	30.986	40	1 239.40	1859.14	40	74 362.6	10 00	416 410	33 766
41	6	1	1 270.39	.14	1	76 221.7	11 00	457 631	40 838
42	6	2	1 301.37	.15	2	78 080.9	12 00	498 732	48 577
43	6	3	1 332.36	.15	3	79 940.0	13 00	539 702	56 979
44	6	4	1 363.34	.16	4	81 799.2	14 00	580 531	66 043
68 45	30.986	45	1 394.33	1859.16	45	83 658.3	15 00	621 207	75 767
46	6	6	1 425.31	.16	6	85 517.5	16 00	661 722	86 148
47	6	7	1 456.30	.17	7	87 376.7	17 00	702 062	97 183
48	6	8	1 487.28	.17	8	89 235.8	18 00	742 219	108 869
49	6	9	1 518.27	.17	9	91 095.0	19 00	782 182	121 204
68 50	30.986	50	1 549.25	1859.18	50	92 954.2	20 00	821 940	134 183
51	6	1	1 580.24	.18	1	94 813.4	21 00	861 482	147 804
52	6	2	1 611.22	.18	2	96 672.6	22 00	900 799	162 064
53	6	3	1 642.21	.19	3	98 531.7	23 00	939 880	176 957
54	7	4	1 673.19	.19	4	100 390.9	24 00	978 715	192 481
68 55	30.987	55	1 704.18	1859.20	55	102 250.1	25 00	1 017 294	208 632
56	7	6	1 735.16	.20	6	104 109.3	26 00	1 055 606	225 404
57	7	7	1 766.15	.20	7	105 968.5	27 00	1 093 642	242 795
58	7	8	1 797.13	.21	8	107 827.7	28 00	1 131 392	260 798
59	7	9	1 828.12	.21	9	109 686.9	29 00	1 168 845	279 411
68 60	30.987	60	1 859.10	1859.21	60	111 546.2	30 00	1 205 992	298 626

Latitude 69° to 70°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
69 00	11.11	22.23	33.34	44.46	55.57	66.69	77.80	88.92	100.03	666.9	1333.7	2000.6	2667.5	3334.3
1	.11	.21	.32	.42	.53	.64	.74	.85	99.95	6.4	2.7	1999.1	5.4	31.8
2	.10	.20	.29	.39	.49	.59	.68	.78	.88	5.9	1.7	7.6	3.4	29.3
3	.09	.18	.27	.36	.45	.54	.63	.72	.80	5.4	30.7	6.1	1.4	6.8
4	.08	.16	.24	.32	.40	.48	.56	.65	.73	4.8	29.7	4.5	59.4	4.2
69 05	11.07	22.14	33.22	44.29	55.36	66.43	77.51	88.58	99.65	664.3	1328.7	1993.0	2657.4	3321.7
6	.06	.13	.19	.26	.32	.38	.45	.51	.58	3.8	7.7	1.5	5.3	19.2
7	.06	.11	.17	.22	.28	.33	.39	.44	.50	3.3	6.7	90.0	3.3	6.6
8	.05	.09	.14	.19	.23	.28	.33	.38	.42	2.8	5.6	88.5	1.3	4.1
9	.04	.08	.12	.15	.19	.23	.27	.31	.35	2.3	4.6	7.0	49.3	11.6
69 10	11.03	22.06	33.09	44.12	55.15	66.18	77.21	88.24	99.27	661.8	1323.6	1985.4	2647.3	3309.1
11	.02	.04	.07	.09	.11	.13	.15	.17	.20	1.3	2.6	3.9	5.2	6.5
12	.01	.03	.04	.05	.07	.08	.09	.11	.12	0.8	1.6	2.4	3.2	4.0
13	.01	2.01	3.02	4.02	5.02	6.03	7.03	8.04	9.04	60.3	20.6	80.9	41.2	301.5
14	1.00	1.99	2.99	3.99	4.98	5.98	6.98	7.97	8.97	59.8	19.6	79.4	39.2	299.0
69 15	10.99	21.98	32.97	43.95	54.94	65.93	76.92	87.90	98.89	659.3	1318.6	1977.9	2637.1	3296.4
16	.98	.96	.94	.92	.90	.88	.86	.84	.82	8.8	7.6	6.3	5.1	3.9
17	.97	.94	.91	.89	.86	.83	.80	.77	.74	8.3	6.6	4.8	3.1	91.4
18	.96	.93	.89	.85	.81	.78	.74	.70	.66	7.8	5.5	3.3	31.1	88.8
19	.96	.91	.86	.82	.77	.73	.68	.63	.59	7.3	4.5	1.8	29.0	6.3
69 20	10.95	21.89	32.84	43.78	54.73	65.68	76.62	87.57	98.51	656.8	1313.5	1970.3	2627.0	3283.8
21	.94	.88	.81	.75	.69	.63	.56	.50	.44	6.3	2.5	68.8	5.0	81.3
22	.93	.86	.79	.72	.65	.57	.50	.43	.36	5.7	1.5	7.2	3.0	78.7
23	.92	.84	.76	.68	.60	.53	.44	.37	.29	5.2	10.4	5.7	20.9	6.2
24	.91	.82	.74	.65	.56	.47	.39	.30	.21	4.7	09.4	4.2	18.9	3.7
69 25	10.90	21.81	32.71	43.61	54.52	65.42	76.33	87.23	98.13	654.2	1308.4	1962.7	2616.9	3271.1
26	.90	.79	.69	.58	.48	.37	.27	.16	8.06	3.7	7.4	61.2	4.9	68.6
27	.89	.77	.66	.55	.44	.32	.21	.10	7.98	3.2	6.4	59.6	2.8	6.1
28	.88	.75	.63	.51	.39	.27	.15	7.03	.90	2.7	5.4	8.1	10.8	3.5
29	.87	.74	.61	.48	.35	.22	.09	6.96	.83	2.2	4.4	6.6	08.8	61.0
69 30	10.86	21.72	32.58	43.45	54.31	65.17	76.03	86.89	97.75	651.7	1303.4	1955.1	2606.8	3258.5
31	.85	.71	.56	.41	.27	.12	5.97	.82	.68	1.2	2.4	3.6	4.7	5.9
32	.84	.69	.53	.38	.22	.07	.91	.76	.60	0.7	1.4	2.0	2.7	3.4
33	.84	.67	.51	.35	.18	5.02	.85	.69	.53	50.2	300.3	50.5	600.7	50.9
34	.83	.66	.48	.31	.14	4.97	.79	.62	.45	49.7	299.3	49.0	598.7	48.3
69 35	10.82	21.64	32.46	43.28	54.10	64.92	75.74	86.55	97.37	649.2	1298.3	1947.5	2596.6	3245.8
36	.81	.62	.43	.24	.06	.87	.68	.49	.30	8.7	7.3	6.0	4.6	3.3
37	.80	.60	.41	.21	4.01	.81	.62	.42	.22	8.1	6.3	4.4	2.6	40.7
38	.79	.59	.38	.18	3.97	.76	.56	.35	.15	7.6	5.3	2.9	90.6	38.2
39	.79	.57	.36	.14	.93	.71	.50	.29	7.07	7.1	4.2	41.4	88.5	5.7
69 40	10.78	21.55	32.33	43.11	53.89	64.66	75.44	86.22	96.99	646.6	1293.2	1939.9	2586.5	3233.1
41	.77	.54	.31	.07	.84	.61	.38	.15	.92	6.1	2.2	8.4	4.5	30.6
42	.76	.52	.28	.04	.80	.56	.32	.08	.84	5.6	1.2	6.8	2.4	28.0
43	.75	.50	.26	3.01	.76	.51	.26	6.01	.77	5.1	90.2	5.3	80.4	5.5
44	.74	.49	.23	2.97	.72	.46	.20	5.95	.69	4.6	89.2	3.8	78.4	3.0
69 45	10.73	21.47	32.20	42.94	53.67	64.41	75.15	85.88	96.61	644.1	1288.2	1932.3	2576.3	3220.4
46	.73	.45	.18	.91	.63	.36	.08	.81	.54	3.6	7.2	30.7	4.3	17.9
47	.72	.44	.15	.87	.59	.31	5.03	.74	.46	3.1	6.2	29.2	2.3	5.4
48	.71	.42	.13	.84	.55	.26	4.97	.67	.38	2.6	5.1	7.7	70.3	2.8
49	.70	.40	.10	.80	.50	.21	.91	.61	.31	2.1	4.1	6.2	68.2	10.3
69 50	10.69	21.39	32.08	42.77	53.46	64.16	74.85	85.54	96.23	641.6	1283.1	1924.7	2566.2	3207.8
51	.68	.37	.05	.74	.42	.11	.79	.47	.16	1.0	2.1	3.1	4.2	5.2
52	.68	.35	.03	.70	.38	.05	.73	.41	.08	0.5	1.1	1.6	2.1	2.7
53	.67	.33	2.00	.67	.33	4.00	.67	.34	6.00	40.0	80.0	20.1	60.1	200.1
54	.66	.32	1.98	.63	.29	3.95	.61	.27	5.93	39.5	79.0	18.6	58.1	197.6
69 55	10.65	21.30	31.95	42.60	53.25	63.90	74.55	85.20	95.85	639.0	1278.0	1917.0	2556.0	3195.1
56	.64	.28	.92	.57	.21	.85	.49	.13	.78	8.5	7.0	5.5	4.0	2.5
57	.63	.27	.90	.53	.17	.80	.43	.07	.70	8.0	6.0	4.0	52.0	90.0
58	.62	.25	.87	.50	.12	.75	.37	5.00	.62	7.5	4.9	2.5	49.9	87.4
59	.62	.23	.85	.47	.08	.70	.31	4.93	.55	7.0	3.9	10.9	7.9	4.9
69 60	10.61	21.22	31.82	42.43	53.04	63.65	74.25	84.86	95.47	636.5	1272.9	1909.4	2545.9	3182.4

Lat.		Latitude 69° to 70°—Meridional arcs.						Latitude 69°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
69	00	30.987			1859.21						
	1	7	1	30.99	.22	1	1 859.2	0	1	666.9	0.1
	2	7	2	61.98	.22	2	3 718.4		2	1 333.7	0.4
	3	7	3	92.97	.23	3	5 577.7		3	2 000.6	0.8
	4	7	4	123.95	.23	4	7 436.9		4	2 667.5	1.5
69	05	30.987	5	154.94	1859.23	5	9 296.1	0	5	3 334.3	2.3
	6	7	6	185.93	.24	6	11 155.4		6	4 001.2	3.3
	7	7	7	216.92	.24	7	13 014.6		7	4 668.1	4.4
	8	7	8	247.91	.24	8	14 873.8		8	5 334.9	5.8
	9	7	9	278.90	.25	9	16 733.1		9	6 001.8	7.3
69	10	30.988	10	309.89	1859.25	10	18 592.3	0	10	6 668.7	9.1
	11	8	1	340.88	.26	1	20 451.6		15	10 003.0	20.4
	12	8	2	371.86	.26	2	22 310.9		20	13 337.3	36.2
	13	8	3	402.85	.26	3	24 170.1		25	16 671.5	56.6
	14	8	4	433.84	.27	4	26 029.4		30	20 005.8	81.5
69	15	30.988	15	464.83	1859.27	15	27 888.6	0	35	23 340.0	110.9
	16	8	6	495.82	.27	6	29 747.9		40	26 674.1	144.9
	17	8	7	526.81	.28	7	31 607.2		45	30 008.2	183.3
	18	8	8	557.80	.28	8	33 466.5		50	33 342.3	226.3
	19	8	9	588.79	.28	9	35 325.8		55	36 676.3	273.9
69	20	30.988	20	619.77	1859.29	20	37 185.0	1	00	40 010.2	325.9
	21	8	1	650.76	.29	1	39 044.3		05	43 344.0	382.5
	22	8	2	681.75	.30	2	40 903.6		10	46 677.8	443.6
	23	8	3	712.74	.30	3	42 762.9		15	50 011.5	509.3
	24	8	4	743.73	.30	4	44 622.2		20	53 345.1	579.5
69	25	30.988	25	774.72	1859.31	25	46 481.5	1	25	56 678.6	654.2
	26	8	6	805.71	.31	6	48 340.8		30	60 012.0	733.4
	27	9	7	836.70	.31	7	50 200.1		35	63 345.3	817.2
	28	9	8	867.68	.32	8	52 059.5		40	66 678.4	905.4
	29	9	9	898.67	.32	9	53 918.8		45	70 011.5	998.2
69	30	30.989	30	929.66	1859.32	30	55 778.1	1	50	73 344.4	1 095.6
	31	9	1	960.65	.33	1	57 637.4		55	76 677.1	1 197.4
	32	9	2	991.64	.33	2	59 496.8	2	00	80 010	1 304
	33	9	3	1 022.63	.34	3	61 356.1	3	00	119 988	2 933
	34	9	4	1 053.62	.34	4	63 215.4	4	00	159 935	5 214
69	35	30.989	35	1 084.61	1859.34	35	65 074.8	5	00	199 839	8 145
	36	9	6	1 115.59	.35	6	66 934.1	6	00	239 690	11 726
	37	9	7	1 146.58	.35	7	68 793.5	7	00	279 477	15 956
	38	9	8	1 177.57	.35	8	70 652.8	8	00	319 190	20 833
	39	9	9	1 208.56	.36	9	72 512.2	9	00	358 818	26 357
69	40	30.989	40	1 239.55	1859.36	40	74 371.5	10	00	398 352	32 526
	41	9	1	1 270.54	.36	1	76 230.9	11	00	437 779	39 338
	42	89	2	1 301.52	.37	2	78 090.3	12	00	477 090	46 792
	43	90	3	1 332.51	.37	3	79 949.6	13	00	516 275	54 885
	44	0	4	1 363.50	.37	4	81 809.0	14	00	555 322	63 615
69	45	30.990	45	1 394.49	1859.38	45	83 668.4	15	00	594 222	72 981
	46	0	6	1 425.48	.38	6	85 527.8	16	00	632 964	82 979
	47	0	7	1 456.47	.39	7	87 387.1	17	00	671 538	93 607
	48	0	8	1 487.46	.39	8	89 246.5	18	00	709 934	104 862
	49	0	9	1 518.45	.39	9	91 105.9	19	00	748 142	116 741
69	50	30.990	50	1 549.44	1859.40	50	92 965.3	20	00	786 150	129 242
	51	0	1	1 580.43	.40	1	94 824.7	21	00	823 950	142 359
	52	0	2	1 611.41	.40	2	96 684.1	22	00	861 532	156 091
	53	0	3	1 642.40	.41	3	98 543.5	23	00	898 884	170 434
	54	0	4	1 673.39	.41	4	100 402.9	24	00	935 998	185 383
69	55	30.990	55	1 704.38	1859.41	55	102 262.4	25	00	972 864	200 935
	56	0	6	1 735.37	.42	6	104 121.8	26	00	1 009 471	217 085
	57	0	7	1 766.36	.42	7	105 981.2	27	00	1 045 810	233 830
	58	0	8	1 797.35	.42	8	107 840.6	28	00	1 081 872	251 165
	59	0	9	1 828.34	.43	9	109 700.0	29	00	1 117 646	269 085
69	60	30.991	60	1 859.32	1859.43	60	111 559.5	30	00	1 153 123	287 585

Latitude 70° to 71°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
70 00	10.61	21.22	31.82	42.43	53.04	63.65	74.25	84.86	95.47	636.5	1272.9	1909.4	2545.9	3182.4
1	.60	.20	.80	.40	3.00	.60	.20	.79	.39	6.0	1.9	7.9	3.8	79.8
2	.59	.18	.77	.36	2.96	.55	.14	.73	.32	5.5	70.9	6.4	41.8	7.3
3	.58	.16	.75	.33	.91	.49	.08	.66	.24	4.9	69.9	4.8	39.8	4.7
4	.57	.15	.72	.30	.87	.44	4.02	.59	.17	4.4	8.9	3.3	7.7	72.2
70 05	10.57	21.13	31.70	42.26	52.83	63.39	73.96	84.52	95.09	633.9	1267.9	1901.8	2535.7	3169.6
6	.56	.11	.67	.23	.79	.34	.90	.46	5.01	3.4	6.9	900.3	3.7	7.1
7	.55	.10	.65	.19	.74	.29	.84	.39	4.94	2.9	5.8	898.7	31.6	4.6
8	.54	.08	.62	.16	.70	.24	.78	.32	.86	2.4	4.8	7.2	29.6	62.0
9	.53	.06	.60	.13	.66	.19	.72	.25	.79	1.9	3.8	5.7	7.6	59.5
70 10	10.52	21.05	31.57	42.09	52.62	63.14	73.66	84.18	94.71	631.4	1262.8	1894.2	2525.5	3156.9
11	.51	.03	.54	.06	.57	.09	.60	.12	.63	0.9	1.8	2.6	3.5	4.4
12	.51	.01	.52	2.02	.53	3.04	.54	4.05	.55	30.4	60.8	91.1	21.5	51.8
13	.50	1.00	.49	1.99	.49	2.99	.48	3.98	.48	29.9	59.7	89.6	19.4	49.3
14	.49	0.98	.47	.96	.45	.93	.42	.91	.40	9.3	8.7	8.0	7.4	6.7
70 15	10.48	20.96	31.44	41.92	52.40	62.88	73.36	83.85	94.33	628.8	1257.7	1886.5	2515.4	3144.2
16	.47	.94	.42	.89	.36	.83	.31	.78	.25	8.3	6.7	5.0	3.3	41.7
17	.46	.93	.39	.85	.32	.78	.25	.71	.17	7.8	5.7	3.5	11.3	39.1
18	.46	.91	.37	.82	.28	.73	.19	.64	.10	7.3	4.6	1.9	09.3	6.6
19	.45	.89	.34	.79	.23	.68	.13	.57	4.02	6.8	3.6	80.4	7.2	4.0
70 20	10.44	20.88	31.31	41.75	52.19	62.63	73.07	83.51	93.94	626.3	1252.6	1878.9	2505.2	3131.5
21	.43	.86	.29	.72	.14	.58	3.01	.44	.87	5.8	1.6	7.4	3.1	28.9
22	.42	.84	.26	.68	.11	.53	2.95	.37	.79	5.3	50.6	5.8	501.1	6.4
23	.41	.83	.24	.65	.06	.48	.89	.30	.71	4.8	49.5	4.3	499.1	3.8
24	.40	.81	.21	.61	2.02	.43	.83	.23	.64	4.3	8.5	2.8	7.0	21.3
70 25	10.40	20.79	31.19	41.58	51.98	62.37	72.77	83.17	93.56	623.7	1247.5	1871.2	2495.0	3118.7
26	.39	.77	.16	.55	.94	.32	.71	.10	.49	3.2	6.5	69.7	2.9	6.2
27	.38	.76	.14	.51	.89	.27	.65	3.03	.41	2.7	5.5	8.2	90.9	3.6
28	.37	.74	.11	.48	.85	.22	.59	2.96	.33	2.2	4.4	6.7	88.9	11.1
29	.36	.72	.09	.45	.81	.17	.53	.89	.26	1.7	3.4	5.1	6.8	08.5
70 30	10.35	20.71	31.06	41.41	51.77	62.12	72.47	82.83	93.18	621.2	1242.4	1863.6	2484.8	3106.0
31	.34	.69	.03	.38	.72	.07	.41	.76	.10	0.7	1.4	2.1	2.7	3.4
32	.34	.67	1.01	.35	.68	2.02	.35	.69	3.03	20.2	40.4	60.5	80.7	100.9
33	.33	.66	0.98	.31	.64	1.97	.29	.62	2.95	19.7	39.3	59.0	78.7	098.3
34	.32	.64	.96	.28	.60	.92	.24	.55	.87	9.2	8.3	7.5	6.6	5.8
70 35	10.31	20.62	30.93	41.24	51.55	61.86	72.17	82.48	92.80	618.6	1237.3	1855.9	2474.6	3093.2
36	.30	.60	.91	.21	.51	.81	.12	.42	.72	8.1	6.3	4.4	2.5	90.7
37	.29	.59	.88	.17	.47	.76	.06	.35	.64	7.6	5.3	2.9	70.5	88.1
38	.29	.57	.86	.14	.43	.71	2.00	.28	.57	7.1	4.2	51.3	68.5	5.6
39	.28	.55	.83	.11	.38	.66	1.94	.21	.49	6.6	3.2	49.8	6.4	3.0
70 40	10.27	20.54	30.80	41.07	51.34	61.61	71.88	82.15	92.41	616.1	1232.2	1848.3	2464.4	3080.5
41	.26	.52	.78	.04	30	.56	.82	.08	.34	5.6	1.2	6.8	2.3	77.9
42	.25	.50	.75	1.01	.26	.51	.76	2.01	.26	5.1	30.2	5.2	60.3	5.4
43	.24	.49	.73	0.97	.21	.46	.71	1.94	.18	4.6	29.1	3.7	58.3	2.8
44	.23	.47	.70	.94	.17	.41	.64	.87	.11	4.1	8.1	2.2	6.2	70.3
70 45	10.23	20.45	30.68	40.90	51.13	61.35	71.58	81.81	92.03	613.5	1227.1	1840.6	2454.2	3067.7
46	.22	.43	.65	.87	.09	.30	.52	.74	1.96	3.0	6.1	39.1	2.1	5.2
47	.21	.42	.63	.83	.04	.25	.46	.67	.88	2.5	5.1	7.6	50.1	2.6
48	.20	.40	.60	.80	1.00	.20	.40	.60	.80	2.0	4.0	6.0	48.0	60.0
49	.19	.38	.58	.77	0.96	.15	.34	.53	.73	1.5	3.0	4.5	6.0	57.5
70 50	10.18	20.37	30.55	40.73	50.92	61.10	71.28	81.46	91.65	611.0	1222.0	1833.0	2444.0	3054.9
51	.17	.35	.52	.70	.87	.05	.22	.40	.57	0.5	1.0	31.4	41.9	52.4
52	.17	.33	.50	.66	.83	1.00	.16	.33	.49	10.0	20.0	29.9	39.9	49.8
53	.16	.32	.47	.63	.79	0.95	.10	.26	.42	09.5	18.9	8.4	7.8	7.3
54	.15	.30	.45	.60	.75	.89	1.04	.19	.34	8.9	7.9	6.8	5.8	4.7
70 55	10.14	20.28	30.42	40.56	50.70	60.84	70.98	81.13	91.27	608.4	1216.9	1825.3	2433.7	3042.2
56	.13	.26	.40	.53	.66	.79	.93	1.06	.19	7.9	5.9	3.8	31.7	39.6
57	.12	.25	.37	.49	.62	.74	.87	0.99	.11	7.4	4.9	2.2	29.6	7.1
58	.12	.23	.34	.46	.58	.69	.81	.92	1.03	6.9	3.8	20.7	7.6	4.5
59	.11	.21	.32	.43	.53	.64	.75	.85	0.96	6.4	2.8	19.2	5.6	31.9
70 60	10.10	20.20	30.29	40.39	50.49	60.59	70.69	80.78	90.88	605.9	1211.8	1817.6	2423.5	3029.4

Lat.	Latitude 70° to 71°—Meridional arcs.						Latitude 70°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
70 00	30.991			1859.43					
1	1	1	30.99	.44	1	1 859.4	0 1	636.5	0.1
2	1	2	61.98	.44	2	3 718.9	2	1 272.9	0.3
3	1	3	92.98	.44	3	5 578.3	3	1 909.4	0.8
4	1	4	123.97	.45	4	7 437.8	4	2 545.9	1.4
70 05	30.991	5	154.96	1859.45	5	9 297.2	0 5	3 182.4	2.2
6	1	6	185.95	.45	6	11 156.7	6	3 818.8	3.1
7	1	7	216.95	.46	7	13 016.1	7	4 455.3	4.3
8	1	8	247.94	.46	8	14 875.6	8	5 091.8	5.6
9	1	9	278.93	.46	9	16 735.0	9	5 728.2	7.0
70 10	30.991	10	309.92	1859.47	10	18 594.5	0 10	6 364.7	8.7
11	1	1	340.92	.47	1	20 454.0	15	9 547.0	19.5
12	1	2	371.91	.47	2	22 313.4	20	12 729.3	34.8
13	1	3	402.90	.48	3	24 172.9	25	15 911.6	54.4
14	1	4	433.89	.48	4	26 032.4	30	19 093.9	78.3
70 15	30.991	15	464.88	1859.49	15	27 891.9	0 35	22 276.1	106.6
16	1	6	495.88	.49	6	29 751.4	40	25 458.3	139.2
17	2	7	526.87	.49	7	31 610.9	45	28 640.4	176.2
18	2	8	557.86	.50	8	33 470.3	50	31 822.5	217.5
19	2	9	588.85	.50	9	35 329.8	55	35 004.5	263.1
70 20	30.992	20	619.85	1859.50	20	37 189.3	1 00	38 186.5	313.1
21	2	1	650.84	.51	1	39 048.9	05	41 368.4	367.5
22	2	2	681.83	.51	2	40 908.4	10	44 550.2	426.2
23	2	3	712.82	.51	3	42 767.9	15	47 731.9	489.3
24	2	4	743.81	.52	4	44 627.4	20	50 913.6	556.7
70 25	30.992	25	774.81	1859.52	25	46 486.9	1 25	54 095.1	628.5
26	2	6	805.80	.52	6	48 346.4	30	57 276.5	704.6
27	2	7	836.79	.53	7	50 206.0	35	60 457.9	785.0
28	2	8	867.78	.53	8	52 065.5	40	63 639.1	869.8
29	2	9	898.78	.53	9	53 925.0	45	66 820.2	959.0
70 30	30.992	30	929.78	1859.54	30	55 784.5	1 50	70 001.2	1 052.5
31	2	1	960.76	.54	1	57 644.1	55	73 182.0	1 150.3
32	2	2	991.75	.54	2	59 503.6	2 00	76 363	1 253
33	2	3	1 022.75	.55	3	61 363.2	3 00	114 518	2 818
34	3	4	1 053.74	.55	4	63 222.7	4 00	152 643	5 009
70 35	30.993	35	1 084.73	1859.55	35	65 082.3	5 00	190 727	7 824
36	3	6	1 115.72	.56	6	66 941.8	6 00	228 760	11 265
37	3	7	1 146.71	.56	7	68 801.4	7 00	266 731	15 328
38	3	8	1 177.71	.57	8	70 661.0	8 00	304 630	20 013
39	3	9	1 208.70	.57	9	72 520.5	9 00	342 447	25 320
70 40	30.993	40	1 239.69	1859.57	40	74 380.1	10 00	380 172	31 246
41	3	1	1 270.68	.58	1	76 239.7	11 00	417 796	37 789
42	3	2	1 301.68	.58	2	78 099.2	12 00	455 306	44 949
43	3	3	1 332.67	.58	3	79 958.8	13 00	492 694	52 723
44	3	4	1 363.66	.59	4	81 818.4	14 00	529 950	61 110
70 45	30.993	45	1 394.65	1859.59	45	83 678.0	15 00	567 063	70 106
46	3	6	1 425.65	.59	6	85 537.6	16 00	604 023	79 709
47	3	7	1 456.64	.60	7	87 397.2	17 00	640 821	89 918
48	3	8	1 487.63	.60	8	89 256.8	18 00	677 447	100 728
49	3	9	1 518.62	.60	9	91 116.4	19 00	713 891	112 138
70 50	30.993	50	1 549.61	1859.61	50	92 976.0	20 00	750 142	124 144
51	3	1	1 580.61	.61	1	94 835.6	21 00	786 191	136 743
52	4	2	1 611.60	.61	2	96 695.2	22 00	822 030	149 931
53	4	3	1 642.59	.62	3	98 554.8	23 00	857 647	163 705
54	4	4	1 673.58	.62	4	100 414.5	24 00	893 033	178 062
70 55	30.994	55	1 704.58	1859.62	55	102 274.1	25 00	928 179	192 997
56	4	6	1 735.57	.63	6	104 133.7	26 00	963 076	208 506
57	4	7	1 766.56	.63	7	105 993.3	27 00	997 713	224 585
58	4	8	1 797.55	.63	8	107 853.0	28 00	1 032 082	241 231
59	4	9	1 828.55	.64	9	109 712.6	29 00	1 066 174	258 438
70 60	30.994	60	1 859.54	1859.64	60	111 572.2	30 00	1 099 979	276 201

Latitude 71° to 72°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
71 00	10.10	20.20	30.29	40.39	50.49	60.59	70.69	80.78	90.88	605.9	1211.8	1817.6	2423.5	3029.4
1	.09	.18	.27	.36	.45	.54	.63	.71	.80	5.4	10.7	6.1	21.5	6.8
2	.08	.16	.24	.32	.40	.49	.57	.65	.73	4.9	09.7	4.6	19.4	4.3
3	.07	.14	.22	.29	.36	.43	.51	.58	.65	4.3	8.7	3.0	7.4	21.7
4	.06	.13	.19	.25	.32	.38	.45	.51	.57	3.8	7.7	1.5	5.3	19.1
71 05	10.06	20.11	30.17	40.22	50.28	60.33	70.39	80.44	90.50	603.3	1206.6	1810.0	2413.3	3016.6
6	.05	.09	.14	.19	.23	.28	.33	.37	.42	2.8	5.6	08.4	11.2	4.0
7	.04	.08	.12	.15	.19	.23	.27	.30	.34	2.2	4.6	6.9	09.2	11.5
8	.03	.06	.09	.12	.15	.18	.21	.24	.27	1.7	3.6	5.3	7.1	08.9
9	.02	.04	.06	.09	.11	.13	.15	.17	.19	1.3	2.6	3.8	5.1	6.4
71 10	10.01	20.03	30.04	40.05	50.06	60.08	70.09	80.10	90.11	600.8	1201.5	1802.3	2403.0	3003.8
11	.00	20.01	30.01	40.02	50.02	60.02	70.03	80.03	90.04	600.2	200.5	800.7	401.0	3001.2
12	10.00	19.99	29.99	39.98	49.98	59.97	69.97	79.97	89.96	599.7	199.5	799.2	398.9	2998.7
13	9.99	.97	.96	.95	.93	.92	.91	.90	.88	9.2	8.4	7.7	6.9	6.1
14	.98	.96	.94	.91	.89	.87	.85	.83	.81	8.7	7.4	6.1	4.8	3.6
71 15	9.97	19.94	29.91	39.88	49.85	59.82	69.79	79.76	89.73	598.2	1196.4	1794.6	2392.8	2991.0
16	.96	.92	.88	.85	.81	.77	.73	.69	.65	7.7	5.4	3.1	90.7	88.4
17	.95	.91	.86	.81	.77	.72	.67	.62	.58	7.2	4.3	1.5	88.7	5.9
18	.94	.89	.83	.78	.72	.67	.61	.55	.50	6.7	3.3	90.0	6.6	3.3
19	.94	.87	.81	.74	.68	.61	.55	.49	.42	6.1	2.3	88.4	4.6	80.7
71 20	9.93	19.85	29.78	39.71	49.64	59.56	69.49	79.42	89.35	595.6	1191.3	1786.9	2382.5	2978.2
21	.92	.84	.76	.67	.59	.51	.43	.35	.27	5.1	90.2	5.4	80.5	5.6
22	.91	.82	.73	.64	.55	.46	.37	.28	.19	4.6	89.2	3.8	78.4	3.1
23	.90	.80	.71	.61	.51	.41	.31	.21	.12	4.1	8.2	2.3	6.4	70.5
24	.89	.79	.68	.57	.47	.36	.25	.14	9.04	3.6	7.2	80.8	4.3	67.9
71 25	9.88	19.77	29.65	39.54	49.42	59.31	69.19	79.08	88.96	593.1	1186.1	1779.2	2372.3	2965.4
26	.88	.75	.63	.50	.38	.26	.13	9.01	.88	2.6	5.1	7.7	70.2	2.8
27	.87	.73	.60	.47	.34	.20	.07	8.94	.81	2.0	4.1	6.1	68.2	60.2
28	.86	.72	.58	.44	.30	.15	9.01	.87	.73	1.5	3.1	4.6	6.1	57.7
29	.85	.70	.55	.40	.25	.10	8.95	.80	.65	1.0	2.0	3.1	4.1	5.1
71 30	9.84	19.68	29.53	39.37	49.21	59.05	68.89	78.73	88.58	590.5	1181.0	1771.5	2362.0	2952.5
31	.83	.67	.50	.33	.17	9.00	.83	.67	.50	90.0	80.0	70.0	60.0	50.0
32	.82	.65	.47	.30	.12	8.95	.77	.60	.42	89.5	79.0	68.4	57.9	47.4
33	.82	.63	.45	.26	.08	.90	.71	.53	.35	9.0	7.9	6.9	5.9	4.8
34	.81	.62	.42	.23	9.04	.85	.65	.46	.27	8.5	6.9	5.4	3.8	42.3
71 35	9.80	19.60	29.40	39.20	48.99	58.79	68.59	78.39	88.20	587.9	1175.9	1763.8	2351.8	2939.7
36	.79	.58	.37	.16	.95	.74	.53	.32	.12	7.4	4.9	2.3	49.7	7.1
37	.78	.56	.35	.13	.91	.69	.47	.26	8.04	6.9	3.8	60.7	7.7	4.6
38	.77	.55	.32	.09	.87	.64	.41	.19	7.96	6.4	2.8	59.2	5.6	32.0
39	.77	.53	.30	.06	.82	.59	.35	.12	.89	5.9	1.8	7.7	3.6	29.5
71 40	9.76	19.51	29.27	39.03	48.78	58.54	68.29	78.05	87.81	585.4	1170.8	1756.1	2341.5	2926.9
41	.75	.50	.24	8.99	.74	.49	.23	7.98	.73	4.9	69.7	4.6	39.5	4.3
42	.74	.48	.22	.96	.69	.43	.17	.91	.66	4.3	8.7	3.0	7.4	21.7
43	.73	.46	.19	.92	.65	.38	.11	.85	.58	3.8	7.7	1.5	5.3	19.2
44	.72	.44	.17	.89	.61	.33	8.05	.78	.50	3.3	6.6	50.0	3.3	6.6
71 45	9.71	19.43	29.14	38.85	48.57	58.28	67.99	77.71	87.42	582.8	1165.6	1748.4	2331.2	2914.0
46	.71	.41	.11	.82	.52	.23	.93	.64	.35	2.3	4.6	6.9	29.2	11.5
47	.70	.39	.09	.79	.48	.18	.87	.57	.27	1.8	3.6	5.3	7.1	08.9
48	.69	.38	.06	.75	.44	.13	.81	.50	.19	1.3	2.5	3.8	5.1	6.3
49	.68	.36	.04	.72	.40	.08	.76	.43	.11	0.8	1.5	2.3	3.0	3.8
71 50	9.67	19.34	29.01	38.68	48.35	58.02	67.69	77.37	87.04	580.2	1160.5	1740.7	2321.0	2901.2
51	.66	.32	8.99	.65	.31	7.97	.63	.30	6.96	79.7	59.4	39.2	18.9	898.6
52	.65	.31	.96	.61	.27	.92	.57	.23	.88	9.2	8.4	7.6	6.8	6.0
53	.64	.29	.93	.58	.22	.87	.51	.16	.81	8.7	7.4	6.1	4.8	3.5
54	.64	.27	.91	.55	.18	.82	.45	.09	.73	8.2	6.4	4.5	2.7	90.9
71 55	9.63	19.26	28.88	38.51	48.14	57.77	67.39	77.02	86.65	577.7	1155.3	1733.0	2310.7	2888.3
56	.62	.24	.86	.48	.10	.72	.34	6.95	.57	7.2	4.3	31.5	08.6	5.8
57	.61	.22	.83	.44	.05	.66	.27	.89	.50	6.6	3.3	29.9	6.6	3.2
58	.60	.20	.81	.41	8.01	.61	.21	.82	.42	6.1	2.2	8.4	4.5	80.6
59	.59	.19	.78	.37	7.96	.56	.15	.75	.34	5.6	1.2	6.8	2.4	78.0
71 60	9.58	19.17	28.75	38.34	47.92	57.51	67.09	76.68	86.26	575.1	1150.2	1725.3	2300.4	2875.5

Lat.	Latitude 71° to 72°—Meridional arcs.						Latitude 71°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
71 00	30.994			1859.64					
1	4	1	31.00	.64	1	1 859.6	0 1	605.9	0.1
2	4	2	61.99	.65	2	3 719.3	2	1 211.8	0.3
3	4	3	92.99	.65	3	5 578.9	3	1 817.6	0.7
4	4	4	123.98	.65	4	7 438.6	4	2 423.5	1.3
71 05	30.994	5	154.98	1859.66	5	9 298.3	0 5	3 029.4	2.1
6	4	6	185.97	.66	6	11 157.9	6	3 635.3	3.0
7	4	7	216.97	.66	7	13 017.6	7	4 241.1	4.1
8	4	8	247.97	.67	8	14 877.2	8	4 847.0	5.3
9	5	9	278.96	.67	9	16 736.9	9	5 452.9	6.7
71 10	30.995	10	309.96	1859.67	10	18 596.6	0 10	6 058.8	8.3
11	5	1	340.95	.68	1	20 456.3	15	9 088.1	18.7
12	5	2	371.95	.68	2	22 315.9	20	12 117.5	33.3
13	5	3	402.94	.68	3	24 175.6	25	15 146.8	52.1
14	5	4	433.94	.69	4	26 035.3	30	18 176.1	75.0
71 15	30.995	15	464.94	1859.69	15	27 895.0	0 35	21 205.4	102.1
16	5	6	495.93	.69	6	29 754.7	40	24 234.6	133.3
17	5	7	526.93	.70	7	31 614.4	45	27 263.8	168.7
18	5	8	557.92	.70	8	33 474.1	50	30 292.9	208.3
19	5	9	588.92	.70	9	35 333.8	55	33 322.0	252.0
71 20	30.995	20	619.91	1859.71	20	37 193.5	1 00	36 351.0	299.9
21	5	1	650.91	.71	1	39 053.2	05	39 379.9	352.0
22	5	2	681.91	.71	2	40 912.9	10	42 408.8	408.3
23	5	3	712.90	.72	3	42 772.7	15	45 437.5	468.7
24	5	4	743.90	.72	4	44 632.4	20	48 466.2	533.2
71 25	30.995	25	774.89	1859.72	25	46 492.1	1 25	51 494.9	602.0
26	5	6	805.89	.73	6	48 351.8	30	54 523.4	674.9
27	6	7	836.88	.73	7	50 211.6	35	57 551.8	751.9
28	6	8	867.88	.73	8	52 071.3	40	60 580.1	833.2
29	6	9	898.88	.74	9	53 931.0	45	63 608.3	918.5
71 30	30.996	30	929.87	1859.74	30	55 790.8	1 50	66 636.3	1 008.1
31	6	1	960.87	.74	1	57 650.5	55	69 664.3	1 101.8
32	6	2	991.86	.75	2	59 510.3	2 00	72 692	1 200
33	6	3	1 022.86	.75	3	61 370.0	3 00	109 013	2 699
34	6	4	1 053.85	.75	4	63 229.8	4 00	145 305	4 798
71 35	30.996	35	1 084.85	1859.76	35	65 089.5	5 00	181 557	7 495
36	6	6	1 115.84	.76	6	66 949.3	6 00	217 760	10 789
37	6	7	1 146.84	.76	7	68 809.1	7 00	253 903	14 681
38	6	8	1 177.84	.77	8	70 668.8	8 00	289 977	19 169
39	6	9	1 208.83	.77	9	72 528.6	9 00	325 972	24 252
71 40	30.996	40	1 239.83	1859.77	40	74 388.4	10 00	361 879	29 927
41	6	1	1 270.82	.78	1	76 248.1	11 00	397 686	36 195
42	6	2	1 301.82	.78	2	78 107.9	12 00	433 386	43 052
43	6	3	1 332.81	.78	3	79 967.7	13 00	468 967	50 498
44	6	4	1 363.81	.79	4	81 827.5	14 00	504 421	58 530
71 45	30.997	45	1 394.81	1859.79	45	83 687.3	15 00	539 738	67 146
46	7	6	1 425.80	.79	6	85 547.1	16 00	574 907	76 343
47	7	7	1 456.80	.80	7	87 406.9	17 00	609 920	86 119
48	7	8	1 487.79	.80	8	89 266.7	18 00	644 767	96 472
49	7	9	1 518.79	.80	9	91 126.5	19 00	679 438	107 399
71 50	30.997	50	1 549.78	1859.81	50	92 986.3	20 00	713 925	118 896
51	7	1	1 580.78	.81	1	94 846.1	21 00	748 216	130 961
52	7	2	1 611.78	.81	2	96 705.9	22 00	782 304	143 590
53	7	3	1 642.77	.82	3	98 565.7	23 00	816 179	156 779
54	7	4	1 673.77	.82	4	100 425.5	24 00	849 832	170 526
71 55	30.997	55	1 704.76	1859.82	55	102 285.4	25 00	883 253	184 827
56	7	6	1 735.76	.83	6	104 145.2	26 00	916 434	199 677
57	7	7	1 766.75	.83	7	106 005.0	27 00	949 365	215 072
58	7	8	1 797.75	.83	8	107 864.9	28 00	982 038	231 009
59	7	9	1 828.75	.84	9	109 724.7	29 00	1 014 443	247 483
71 60	30.997	60	1 859.74	1859.84	60	111 584.5	30 00	1 046 572	264 489

Latitude 72° to 73°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
72 00	9.58	19.17	28.75	38.34	47.92	57.51	67.09	76.68	86.26	575.1	1150.2	1725.3	2300.4	2875.5
1	.57	.15	.73	.31	.88	.46	7.03	.61	.19	4.6	49.2	3.7	298.3	2.9
2	.56	.14	.70	.27	.84	.41	6.97	.54	.11	4.1	8.1	2.2	6.3	70.3
3	.56	.12	.68	.24	.80	.36	.92	.47	6.03	3.6	7.1	20.7	4.2	67.8
4	.55	.10	.65	.20	.75	.30	.85	.41	5.96	3.0	6.1	19.1	2.1	5.2
72 05	9.54	19.08	28.63	38.17	47.71	57.25	66.79	76.34	85.88	572.5	1145.0	1717.6	2290.1	2862.6
6	.53	.07	.60	.13	.67	.20	.73	.27	.80	2.0	4.0	6.0	88.0	60.0
7	.52	.05	.58	.10	.63	.15	.67	.20	.72	1.5	3.0	4.5	6.0	57.5
8	.52	.03	.55	.07	.58	.10	.61	.13	.65	1.0	2.0	2.9	3.9	4.9
9	.51	.02	.52	.03	.54	7.05	.55	6.06	.57	70.5	40.9	11.4	81.8	2.3
72 10	9.50	19.00	28.50	38.00	47.50	56.99	66.49	75.99	85.49	569.9	1139.9	1709.8	2279.8	2849.7
11	.49	8.98	.47	7.96	.45	.94	.43	.93	.42	9.4	8.9	8.3	7.7	7.2
12	.48	.96	.45	.93	.41	.89	.37	.86	.34	8.9	7.8	6.8	5.7	4.6
13	.47	.95	.42	.89	.37	.84	.31	.79	.26	8.4	6.8	5.2	3.6	42.0
14	.46	.93	.39	.86	.32	.79	.25	.72	.18	7.9	5.8	3.7	71.5	39.4
72 15	9.46	18.91	28.37	37.83	47.28	56.74	66.19	75.65	85.11	567.4	1134.7	1702.1	2269.5	2836.9
16	.45	.90	.34	.79	.24	.69	.13	.58	5.03	6.9	3.7	700.6	7.4	4.3
17	.44	.88	.32	.76	.20	.63	.07	.51	4.95	6.3	2.7	699.0	5.4	31.7
18	.43	.86	.29	.72	.15	.58	6.01	.44	.87	5.8	1.7	7.5	3.3	29.1
19	.42	.84	.27	.69	.11	.53	5.95	.38	.80	5.3	30.6	5.9	61.2	6.6
72 20	9.41	18.83	28.24	37.65	47.07	56.48	65.89	75.31	84.72	564.8	1129.6	1694.4	2259.2	2824.0
21	.40	.81	.21	.62	7.02	.43	.83	.24	.64	4.3	8.6	2.8	7.1	21.4
22	.40	.79	.19	.58	6.98	.38	.77	.17	.56	3.8	7.5	91.3	5.1	18.8
23	.39	.77	.16	.55	.94	.32	.71	.10	.49	3.2	6.5	89.7	3.0	6.2
24	.38	.76	.14	.52	.90	.27	.65	5.03	.41	2.7	5.5	8.2	50.9	3.7
72 25	9.37	18.74	28.11	37.48	46.85	56.22	65.59	74.96	84.33	562.2	1124.4	1686.6	2248.9	2811.1
26	.36	.72	.08	.45	.81	.17	.53	.89	.26	1.7	3.4	5.1	6.8	08.5
27	.35	.71	.06	.41	.77	.12	.47	.82	.18	1.2	2.4	3.6	4.7	5.9
28	.34	.69	.03	.38	.72	.07	.41	.75	.10	0.7	1.3	2.0	2.7	3.3
29	.34	.67	8.01	.34	.68	6.02	.35	.69	4.02	60.2	20.3	80.5	40.6	800.8
72 30	9.33	18.65	27.98	37.31	46.64	55.96	65.29	74.62	83.95	559.6	1119.3	1678.9	2238.6	2798.2
31	.32	.64	.96	.27	.59	.91	.23	.55	.87	9.1	8.2	7.4	6.5	5.6
32	.31	.62	.93	.24	.55	.86	.17	.48	.79	8.6	7.2	5.8	4.4	3.0
33	.30	.60	.90	.21	.51	.81	.11	.41	.71	8.1	6.2	4.3	2.4	90.4
34	.29	.59	.88	.17	.47	.76	5.05	.34	.64	7.6	5.1	2.7	30.3	87.9
72 35	9.28	18.57	27.85	37.14	46.42	55.71	64.99	74.27	83.56	557.1	1114.1	1671.2	2228.2	2785.3
36	.28	.55	.83	.10	.38	.65	.93	.21	.48	6.5	3.1	69.6	6.2	2.7
37	.27	.53	.80	.07	.34	.60	.87	.14	.40	6.0	2.0	8.1	4.1	80.1
38	.26	.51	.77	.03	.29	.55	.81	.07	.32	5.5	1.0	6.5	2.0	77.5
39	.25	.50	.75	7.00	.25	.50	.75	4.00	.25	5.0	10.0	5.0	20.0	5.0
72 40	9.24	18.48	27.72	36.97	46.21	55.45	64.69	73.93	83.17	554.5	1109.0	1663.4	2217.9	2772.4
41	.23	.47	.70	.93	.16	.40	.63	.86	.09	4.0	7.9	1.9	5.8	69.8
42	.22	.45	.67	.90	.12	.34	.57	.79	3.02	3.4	6.9	60.3	3.8	7.2
43	.22	.43	.65	.86	.08	.29	.51	.72	2.94	2.9	5.8	58.8	11.7	4.6
44	.21	.41	.62	.83	6.03	.24	.45	.65	.86	2.4	4.8	7.2	09.6	62.0
72 45	9.20	18.40	27.60	36.79	45.99	55.19	64.39	73.59	82.78	551.9	1103.8	1655.7	2207.6	2759.5
46	.19	.38	.57	.76	.95	.14	.33	.52	.71	1.4	2.7	4.1	5.5	6.9
47	.18	.36	.54	.72	.91	.09	.27	.45	.63	0.9	1.7	2.6	3.4	4.3
48	.17	.34	.52	.69	.86	5.03	.21	.38	.55	50.3	100.7	51.0	201.4	51.7
49	.16	.33	.49	.65	.82	4.98	.15	.31	.47	49.8	099.6	49.5	199.3	49.1
72 50	9.16	18.31	27.47	36.62	45.78	54.93	64.09	73.24	82.40	549.3	1098.6	1647.9	2197.2	2746.5
51	.15	.29	.44	.59	.73	.88	4.03	.17	.32	8.8	7.6	6.4	5.2	4.0
52	.14	.28	.41	.55	.69	.83	3.97	.10	.24	8.3	6.5	4.8	3.1	41.4
53	.13	.26	.39	.52	.65	.78	.91	3.03	.16	7.8	5.5	3.3	91.0	38.8
54	.12	.24	.36	.48	.60	.72	.84	2.97	.09	7.2	4.5	1.7	89.0	6.2
72 55	9.11	18.22	27.34	36.45	45.56	54.67	63.78	72.90	82.01	546.7	1093.4	1640.2	2186.9	2733.6
56	.10	.21	.31	.41	.52	.62	.72	.83	1.93	6.2	2.4	38.6	4.8	31.0
57	.09	.19	.28	.38	.47	.57	.66	.76	.85	5.7	1.4	7.1	2.8	28.4
58	.09	.17	.26	.35	.43	.52	.60	.69	.78	5.2	90.4	5.5	80.7	5.9
59	.08	.16	.23	.31	.39	.47	.54	.62	.70	4.7	89.3	4.0	78.6	3.3
72 60	9.07	18.14	27.21	36.28	45.35	54.41	63.48	72.55	81.62	544.1	1088.3	1632.4	2176.5	2720.7

Lat.		Latitude 72° to 73°—Meridional arcs.						Latitude 72°—Co-ordinates of curvature.			
		Value of 1''	Sums of seconds for middle latitude.		Value of 1'	Sums of minutes for middle latitude.		Longitude.		X	Y
°	'	*Meters.*	''	*Meters.*	*Meters.*	'	*Meters.*	°	'	*Meters.*	*Meters.*
72	00	30.997			1859.84						
	1	7	1	31.00	.84	1	1 859.8	0	1	575.1	0.1
	2	7	2	62.00	.85	2	3 719.7		2	1 150.2	0.3
	3	7	3	93.00	.85	3	5 579.5		3	1 725.3	0.7
	4	8	4	124.00	.85	4	7 439.4		4	2 300.4	1.3
72	05	30.998	5	154.99	1859.86	5	9 299.2	0	5	2 875.5	2.0
	6	8	6	185.99	.86	6	11 159.1		6	3 450.6	2.9
	7	8	7	216.99	.86	7	13 019.0		7	4 025.7	3.9
	8	8	8	247.99	.87	8	14 878.8		8	4 600.8	5.1
	9	8	9	278.99	.87	9	16 738.7		9	5 175.9	6.4
72	10	30.998	10	309.99	1859.87	10	18 598.6	0	10	5 751.0	8.0
	11	8	1	340.99	.88	1	20 458.4		15	8 626.4	17.9
	12	8	2	371.99	.88	2	22 318.3		20	11 501.9	31.8
	13	8	3	402.99	.88	3	24 178.2		25	14 377.3	49.7
	14	8	4	433.99	.89	4	26 038.1		30	17 252.7	71.6
72	15	30.998	15	464.98	1859.89	15	27 898.0	0	35	20 128.1	97.5
	16	8	6	495.98	.89	6	29 757.9		40	23 003.4	127.3
	17	8	7	526.98	.89	7	31 617.7		45	25 878.7	161.1
	18	8	8	557.98	.90	8	33 477.6		50	28 753.9	198.9
	19	8	9	588.99	.90	9	35 337.5		55	31 629.1	240.6
72	20	30.998	20	619.98	1859.90	20	37 197.4	1	00	34 504.2	286.4
	21	8	1	650.98	.91	1	39 057.3		05	37 379.2	336.1
	22	9	2	681.98	.91	2	40 917.3		10	40 254.2	389.8
	23	9	3	712.98	.91	3	42 777.2		15	43 129.1	447.5
	24	9	4	743.97	.92	4	44 637.1		20	46 003.9	509.1
72	25	30.999	25	774.97	1859.92	25	46 497.0	1	25	48 878.7	574.7
	26	9	6	805.97	.92	6	48 356.9		30	51 753.3	644.3
	27	9	7	836.97	.93	7	50 216.8		35	54 627.9	717.9
	28	9	8	867.97	.93	8	52 076.8		40	57 502.3	795.5
	29	9	9	898.97	.93	9	53 936.7		45	60 376.6	877.0
72	30	30.999	30	929.97	1859.94	30	55 796.6	1	50	63 250.8	962.5
	31	9	1	960.97	.94	1	57 656.6		55	66 124.9	1 052.0
	32	9	2	991.97	.94	2	59 516.5	2	00	68 999	1 145
	33	9	3	1 022.96	.95	3	61 376.5	3	00	103 475	2 577
	34	9	4	1 053.96	.95	4	63 236.4	4	00	137 922	4 580
72	35	30.999	35	1 084.96	1859.95	35	65 096.4	5	00	172 331	7 155
	36	9	6	1 115.96	.96	6	66 956.3	6	00	206 693	10 301
	37	9	7	1 146.96	.96	7	68 816.3	7	00	240 997	14 017
	38	9	8	1 177.96	.96	8	70 676.2	8	00	275 236	18 302
	39	9	9	1 208.96	.96	9	72 536.2	9	00	309 398	23 154
72	40	30.999	40	1 239.96	1859.97	40	74 396.2	10	00	343 475	28 572
	41	31.000	1	1 270.96	.97	1	76 256.1	11	00	377 458	34 556
	42	0	2	1 301.96	.97	2	78 116.1	12	00	411 337	41 103
	43	0	3	1 332.95	.98	3	79 976.1	13	00	445 102	48 211
	44	0	4	1 363.95	.98	4	81 836.1	14	00	478 745	55 879
72	45	31.000	45	1 394.95	1859.98	45	83 696.1	15	00	512 255	64 104
	46	0	6	1 425.95	.99	6	85 556.1	16	00	545 625	72 884
	47	0	7	1 456.95	.99	7	87 416.0	17	00	578 844	82 217
	48	0	8	1 487.95	59.99	8	89 276.0	18	00	611 904	92 100
	49	0	9	1 518.95	60.00	9	91 136.0	19	00	644 795	102 530
72	50	31.000	50	1 549.95	1860.00	50	92 996.0	20	00	677 509	113 505
	51	0	1	1 580.95	.00	1	94 856.0	21	00	710 036	125 021
	52	0	2	1 611.94	.01	2	96 716.0	22	00	742 367	137 075
	53	0	3	1 642.94	.01	3	98 576.0	23	00	774 494	149 665
	54	0	4	1 673.94	1860.01	4	100 436.0	24	00	806 407	162 786
72	55	31.000	55	1 704.94	.01	55	102 296.1	25	00	838 098	176 435
	56	0	6	1 735.94	.02	6	104 156.1	26	00	869 558	190 608
	57	0	7	1 766.94	.02	7	106 016.1	27	00	900 779	205 301
	58	0	8	1 797.94	.02	8	107 876.1	28	00	931 751	220 511
	59	0	9	1 828.94	.03	9	109 736.1	29	00	962 467	236 232
72	60	31.001	60	1 859.94	1860.03	0	111 596.2	30	00	992 918	252 461

Latitude 73° to 74°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
73 00	9.07	18.14	27.21	36.28	45.35	54.41	63.48	72.55	81.62	544.1	1088.3	1632.4	2176.5	2720.7
1	.06	.12	.18	.24	.30	.36	.42	.48	.54	3.6	7.2	30.9	4.5	18.1
2	.05	.10	.16	.21	.26	.31	.36	.41	.47	3.1	6.2	29.3	2.4	5.5
3	.04	.09	.13	.17	.22	.26	.30	.34	.39	2.6	5.2	7.7	70.3	2.9
4	.03	.07	.10	.14	.17	.21	.24	.27	.31	2.1	4.1	6.2	68.3	10.3
73 05	9.03	18.05	27.08	36.10	45.13	54.15	63.18	72.21	81.23	541.5	1083.1	1624.6	2166.2	2707.7
6	.02	.03	.05	.07	.09	.10	.12	.14	.16	1.0	2.1	3.1	4.1	5.2
7	.01	.02	.03	.04	.04	.05	.06	.07	.08	0.5	1.0	1.5	2.0	2.6
8	9.00	8.00	7.00	6.00	5.00	4.00	3.00	2.00	1.00	40.0	80.0	20.0	60.0	700.0
9	8.99	7.98	6.97	5.97	4.96	3.95	2.94	1.93	0.92	39.5	79.0	18.4	57.9	697.4
73 10	8.98	17.97	26.95	35.93	44.91	53.90	62.88	71.86	80.84	539.0	1077.9	1616.9	2155.8	2694.8
11	.97	.95	.92	.90	.87	.84	.82	.79	.77	8.4	6.9	5.3	3.8	92.2
12	.97	.93	.90	.86	.83	.79	.76	.72	.69	7.9	5.8	3.8	51.7	89.6
13	.96	.91	.87	.83	.78	.74	.70	.65	.61	7.4	4.8	2.2	49.6	7.0
14	.95	.90	.84	.79	.74	.69	.64	.58	.53	6.9	3.8	0.7	7.5	4.4
73 15	8.94	17.88	26.82	35.76	44.70	53.64	62.58	71.52	80.45	536.4	1072.7	1609.1	2145.5	2681.8
16	.93	.86	.79	.72	.65	.59	.52	.45	.38	5.9	1.7	7.6	3.4	79.3
17	.92	.84	.77	.69	.61	.53	.46	.38	.30	5.3	70.7	6.0	41.3	6.7
18	.91	.83	.74	.65	.57	.48	.40	.31	.22	4.8	69.6	4.4	39.3	4.1
19	.91	.81	.72	.62	.52	.43	.33	.24	.15	4.3	8.6	2.9	7.2	71.5
73 20	8.90	17.79	26.69	35.59	44.48	53.38	62.27	71.17	80.07	533.8	1067.6	1601.3	2135.1	2668.9
21	.89	.78	.66	.55	.44	.33	.21	.10	79.99	3.3	6.5	599.8	3.0	6.3
22	.88	.76	.64	.52	.39	.27	.15	1.03	.91	2.7	5.5	8.2	31.0	3.7
23	.87	.74	.61	.48	.35	.22	.09	0.96	.83	2.2	4.4	6.7	28.9	61.1
24	.86	.72	.59	.45	.31	.17	2.03	.89	.76	1.7	3.4	5.1	6.8	58.5
73 25	8.85	17.71	26.56	35.41	44.26	53.12	61.97	70.82	79.68	531.2	1062.4	1593.6	2124.7	2655.9
26	.84	.69	.53	.38	.22	.07	.91	.75	.60	0.7	1.3	2.0	2.7	3.3
27	.84	.67	.51	.34	.18	3.01	.85	.69	.52	30.1	60.3	90.4	20.6	50.7
28	.83	.65	.48	.31	.14	2.96	.79	.62	.45	29.6	59.3	88.9	18.5	48.2
29	.82	.64	.46	.27	.09	.91	.73	.55	.37	9.1	8.2	7.3	6.4	5.6
73 30	8.81	17.62	26.43	35.24	44.05	52.86	61.67	70.48	79.29	528.6	1057.2	1585.8	2114.4	2643.0
31	.80	.60	.40	.21	4.01	.81	.61	.41	.21	8.1	6.2	4.2	2.3	40.4
32	.79	.59	.38	.17	3.96	.76	.55	.34	.13	7.6	5.1	2.7	19.2	37.8
33	.78	.57	.35	.14	.92	.70	.49	.27	9.06	7.0	4.1	81.1	08.1	5.2
34	.78	.55	.33	.10	.88	.65	.43	.20	8.98	6.5	3.0	79.6	6.1	2.6
73 35	8.77	17.53	26.30	35.07	43.83	52.60	61.37	70.13	78.90	526.0	1052.0	1578.0	2104.0	2630.0
36	.76	.52	.27	.03	.79	.55	.31	70.06	.82	5.5	51.0	6.4	101.9	27.4
37	.75	.50	.25	5.00	.75	.50	.25	69.99	.74	5.0	49.9	4.9	099.8	4.8
38	.74	.48	.22	4.96	.70	.44	.18	.93	.67	4.4	8.9	3.3	7.8	22.2
39	.73	.46	.20	.93	.66	.39	.12	.86	.59	3.9	7.8	1.8	5.7	19.6
73 40	8.72	17.45	26.17	34.89	43.62	52.34	61.07	69.79	78.51	523.4	1046.8	1570.2	2093.6	2617.0
41	.71	.43	.14	.86	.57	.29	1.00	.72	.43	2.9	5.8	68.7	91.5	4.4
42	.71	.41	.12	.82	.53	.24	0.94	.65	.35	2.4	4.7	7.1	89.5	11.8
43	.70	.39	.09	.79	.49	.18	.88	.58	.28	1.8	3.7	5.5	7.4	09.2
44	.69	.38	.07	.75	.44	.13	.82	.51	.20	1.3	2.7	4.0	5.3	6.6
73 45	8.68	17.36	26.04	34.72	43.40	52.08	60.76	69.44	78.12	520.8	1041.6	1562.4	2083.2	2604.0
46	.67	.34	6.01	.69	.36	2.03	.70	.37	8.04	20.3	40.6	60.9	81.2	601.4
47	.66	.33	5.99	.65	.31	1.98	.64	.30	7.96	19.8	39.5	59.3	79.1	598.8
48	.65	.31	.96	.62	.27	.92	.58	.23	.89	9.2	8.5	7.7	7.0	6.2
49	.65	.29	.94	.58	.23	.87	.52	.16	.81	8.7	7.5	6.2	4.9	3.6
73 50	8.64	17.27	25.91	34.55	43.18	51.82	60.46	69.09	77.73	518.2	1036.4	1554.6	2072.8	2591.0
51	.63	.26	.88	.51	.14	.77	.40	9.02	.65	7.7	5.4	3.1	70.8	88.4
52	.62	.24	.86	.48	.10	.72	.34	8.95	.57	7.2	4.3	51.5	68.7	5.8
53	.61	.22	.83	.44	.05	.66	.27	.89	.50	6.6	3.3	49.9	6.6	3.2
54	.60	.20	.81	.41	3.01	.61	.22	.82	.42	6.1	2.3	8.4	4.5	80.6
73 55	8.59	17.19	25.78	34.37	42.97	51.56	60.15	68.75	77.34	515.6	1031.2	1546.8	2062.4	2578.0
56	.58	.17	.75	.34	.92	.51	.09	.68	.26	5.1	30.2	5.3	60.4	5.4
57	.58	.15	.73	.30	.88	.46	60.03	.61	.18	4.6	29.1	3.7	58.3	2.8
58	.57	.13	.70	.27	.84	.40	59.97	.54	.11	4.0	8.1	2.1	6.2	70.2
59	.56	.12	.68	.23	.79	.35	.91	.47	7.03	3.5	7.1	40.6	4.1	67.6
73 60	8.55	17.10	25.65	34.20	42.75	51.30	59.85	68.40	76.95	513.0	1026.0	1539.0	2052.0	2565.0

Lat.		Latitude 73° to 74°—Meridional arcs.						Latitude 73°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
73	00	31.001			1860.03						
	1	1	1	31.00	.03	1	1 860.0	0	1	544.1	0.1
	2	1	2	62.00	.04	2	3 720.1		2	1 088.3	0.3
	3	1	3	93.01	.04	3	5 580.1		3	1 632.4	0.7
	4	1	4	124.01	.04	4	7 440.2		4	2 176.6	1.2
73	05	31.001	5	155.01	1860.05	5	9 300.2	0	5	2 720.7	1.9
	6	1	6	186.01	.05	6	11 160.2		6	3 264.8	2.7
	7	1	7	217.01	.05	7	13 020.3		7	3 809.0	3.7
	8	1	8	248.02	.05	8	14 880.4		8	4 353.1	4.8
	9	1	9	279.02	.06	9	16 740.4		9	4 897.2	6.1
73	10	31.001	10	310.02	1860.06	10	18 600.5	0	10	5 441.4	7.6
	11	1	1	341.02	.06	1	20 460.5		15	8 162.0	17.0
	12	1	2	372.02	.07	2	22 320.6		20	10 882.7	30.3
	13	1	3	403.03	.07	3	24 180.7		25	13 603.3	47.3
	14	1	4	434.03	.07	4	26 040.7		30	16 323.9	68.1
73	15	31.001	15	465.03	1860.08	15	27 900.8	0	35	19 044.5	92.7
	16	1	6	496.03	.08	6	29 760.9		40	21 765.0	121.1
	17	1	7	527.03	.08	7	31 621.0		45	24 485.5	153.3
	18	1	8	558.04	.09	8	33 481.1		50	27 206.0	189.2
	19	1	9	589.04	.09	9	35 341.1		55	29 926.4	228.9
73	20	31.002	20	620.04	1860.09	20	37 201.2	1	00	32 646.7	272.4
	21	2	1	651.04	.09	1	39 061.3		05	35 367.0	319.7
	22	2	2	682.04	.10	2	40 921.4		10	38 087.2	370.8
	23	2	3	713.05	.10	3	42 781.5		15	40 807.3	425.7
	24	2	4	744.05	.10	4	44 641.6		20	43 527.4	484.3
73	25	31.002	25	775.05	1860.11	25	46 501.7	1	25	46 247.3	546.8
	26	2	6	806.05	.11	6	48 361.8		30	48 967.2	613.0
	27	2	7	837.05	.11	7	50 221.9		35	51 687.0	683.0
	28	2	8	868.06	.12	8	52 082.1		40	54 406.7	756.8
	29	2	9	899.06	.12	9	53 942.2		45	57 126.3	834.3
73	30	31.002	30	930.06	1860.12	30	55 802.3	1	50	59 845.8	915.7
	31	2	1	961.06	.12	1	57 662.4		55	62 565.1	1 000.8
	32	2	2	992.06	.13	2	59 522.5	2	00	65 284	1 090
	33	2	3	1 023.07	.13	3	61 382.7	3	00	97 904	2 452
	34	2	4	1 054.07	.13	4	63 242.8	4	00	130 496	4 358
73	35	31.002	35	1 085.07	1860.14	35	65 102.9	5	00	163 052	6 808
	36	2	6	1 116.07	.14	6	66 963.1	6	00	195 562	9 800
	37	2	7	1 147.07	.14	7	68 823.2	7	00	228 018	13 335
	38	2	8	1 178.08	.15	8	70 683.4	8	00	260 410	17 412
	39	2	9	1 209.08	.15	9	72 543.5	9	00	292 730	22 028
73	40	31.003	40	1 240.08	1860.15	40	74 403.7	10	00	324 968	27 183
	41	3	1	1 271.08	.15	1	76 263.8	11	00	357 116	32 875
	42	3	2	1 302.09	.16	2	78 124.0	12	00	389 165	39 103
	43	3	3	1 333.09	.16	3	79 984.1	13	00	421 104	45 865
	44	3	4	1 364.09	.16	4	81 844.3	14	00	452 927	53 160
73	45	31.003	45	1 395.09	1860.17	45	83 704.5	15	00	484 623	60 984
	46	3	6	1 426.09	.17	6	85 564.6	16	00	516 185	69 336
	47	3	7	1 457.10	.17	7	87 424.8	17	00	547 602	78 214
	48	3	8	1 488.10	.18	8	89 285.0	18	00	578 868	87 615
	49	3	9	1 519.10	.18	9	91 145.2	19	00	609 971	97 537
73	50	31.003	50	1 550.10	1860.18	50	93 005.4	20	00	640 905	107 976
	51	3	1	1 581.10	.18	1	94 865.5	21	00	671 661	118 930
	52	3	2	1 612.11	.19	2	96 725.7	22	00	702 229	130 396
	53	3	3	1 643.11	.19	3	98 585.9	23	00	732 601	142 370
	54	3	4	1 674.11	.19	4	100 446.1	24	00	762 770	154 850
73	55	31.003	55	1 705.11	1860.20	55	102 306.3	25	00	792 726	167 831
	56	3	6	1 736.11	.20	6	104 166.5	26	00	822 461	181 311
	57	3	7	1 767.12	.20	7	106 026.7	27	00	851 967	195 285
	58	3	8	1 798.12	.21	8	107 886.9	28	00	881 236	209 749
	59	3	9	1 829.12	.21	9	109 747.1	29	00	910 259	224 700
73	60	31.004	60	1 860.12	1860.21	60	111 607.3	30	00	939 029	240 134

Latitude 74° to 75°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
74 00	8.55	17.10	25.65	34.20	42.75	51.30	59.85	68.40	76.95	513.0	1026.0	1539.0	2052.0	2565.0
1	.54	.08	.62	.17	.71	.25	.79	.33	.87	2.5	5.0	7.5	50.0	62.4
2	.53	.07	.60	.13	.66	.20	.73	.26	.80	2.0	3.9	5.9	47.9	59.8
3	.52	.05	.57	.10	.62	.14	.67	.19	.72	1.4	2.9	4.3	5.8	7.2
4	.51	.03	.55	.06	.58	.09	.61	.12	.64	0.9	1.9	2.8	3.7	4.6
74 05	8.51	17.01	25.52	34.03	42.53	51.04	59.55	68.06	76.56	510.4	1020.8	1531.2	2041.6	2552.0
6	.50	7.00	.49	3.99	.49	0.99	.49	7.98	.48	09.9	19.8	29.7	39.5	49.4
7	.49	6.98	.47	.96	.45	.94	.42	.92	.40	9.4	8.7	8.1	7.5	6.8
8	.48	.96	.44	.92	.41	.88	.36	.85	.33	8.8	7.7	6.5	5.4	4.2
9	.47	.94	.42	.89	.36	.83	.30	.78	.25	8.3	6.6	5.0	3.3	41.6
74 10	8.46	16.93	25.39	33.85	42.32	50.78	59.24	67.71	76.17	507.8	1015.6	1523.4	2031.2	2539.0
11	.45	.91	.36	.82	.28	.73	.18	.64	.09	7.3	4.6	1.8	29.1	6.4
12	.45	.89	.34	.78	.23	.68	.12	.57	6.01	6.8	3.5	20.3	7.0	3.8
13	.44	.87	.31	.75	.19	.62	.06	.50	5.94	6.2	2.5	18.7	5.0	31.2
14	.43	.86	.29	.71	.14	.57	9.00	.43	.86	5.7	1.4	7.2	2.9	28.6
74 15	8.42	16.84	25.26	33.68	42.10	50.52	58.94	67.36	75.78	505.2	1010.4	1515.6	2020.8	2526.0
16	.41	.82	.23	.65	.06	.47	.88	.29	.70	4.7	09.4	4.0	18.7	3.4
17	.40	.81	.21	.61	2.01	.42	.82	.22	.62	4.2	8.3	2.5	6.6	20.8
18	.40	.79	.18	.58	1.97	.36	.76	.15	.55	3.6	7.3	10.9	4.5	18.2
19	.39	.77	.16	.54	.92	.31	.70	.08	.47	3.1	6.2	09.3	2.5	5.6
74 20	8.38	16.75	25.13	33.51	41.88	50.26	58.64	67.01	75.39	502.6	1005.2	1507.8	2010.4	2513.0
21	.37	.74	.10	.47	.84	.21	.58	6.94	.31	2.1	4.1	6.2	08.3	10.4
22	.36	.72	.08	.44	.80	.16	.52	.87	.23	1.6	3.1	4.7	6.2	07.8
23	.35	.70	.05	.40	.75	.10	.46	.80	.16	1.0	2.1	3.1	4.1	5.2
24	.34	.68	.03	.37	.71	.05	.39	.73	.08	0.5	1.0	1.5	2.0	2.6
74 25	8.33	16.67	25.00	33.33	41.67	50.00	58.33	66.67	75.00	500.0	1000.0	1500.0	2000.0	2500.0
26	.32	.65	4.97	.30	.62	49.95	.27	.60	4.92	499.5	998.9	498.4	1997.9	497.3
27	.32	.63	.95	.26	.58	.89	.21	.53	.84	8.9	7.9	6.8	5.8	4.7
28	.31	.61	.92	.23	.53	.84	.15	.46	.76	8.4	6.9	5.3	3.7	92.1
29	.30	.60	.90	.19	.49	.79	.09	.39	.69	7.9	5.8	3.7	91.6	89.5
74 30	8.29	16.58	24.87	33.16	41.45	49.74	58.03	66.32	74.61	497.4	994.8	1492.2	1989.5	2486.9
31	.28	.56	.84	.12	.41	.69	7.97	.25	.53	6.9	3.7	90.6	7.5	4.3
32	.27	.54	.82	.09	.36	.63	.91	.18	.45	6.3	2.7	89.0	5.4	81.7
33	.26	.53	.79	.05	.32	.58	.85	.11	.37	5.8	1.6	7.5	3.3	79.1
34	.25	.51	.77	3.02	.27	.53	.79	6.04	.30	5.3	90.6	5.9	81.2	6.5
74 35	8.25	16.49	24.74	32.99	41.23	49.48	57.72	65.97	74.22	494.8	989.6	1484.3	1979.1	2473.9
36	.24	.48	.71	.95	.19	.43	.66	.90	.14	4.3	8.5	2.8	7.0	71.3
37	.23	.46	.69	.92	.14	.37	.60	.83	4.06	3.7	7.5	81.2	4.9	68.7
38	.22	.44	.66	.88	.10	.32	.54	.76	3.98	3.2	6.4	79.6	2.8	6.1
39	.21	.42	.64	.85	.06	.27	.48	.69	.91	2.7	5.4	8.1	70.8	3.5
74 40	8.20	16.41	24.61	32.81	41.01	49.22	57.42	65.62	73.82	492.2	984.3	1476.5	1968.7	2460.8
41	.19	.39	.58	.78	0.97	.16	.36	.55	.75	1.6	3.3	4.9	6.6	58.2
42	.19	.37	.56	.74	.92	.11	.30	.48	.67	1.1	2.2	3.4	4.5	5.6
43	.18	.35	.53	.71	.88	.06	.24	.41	.59	0.6	1.2	1.8	2.4	3.0
44	.17	.34	.50	.67	.84	9.01	.18	.34	.51	90.1	80.2	70.2	60.3	50.4
74 45	8.16	16.32	24.48	32.64	40.80	48.96	57.11	65.27	73.43	489.6	979.1	1468.7	1958.2	2447.8
46	.15	.30	.45	.60	.75	.90	7.05	.21	.36	9.0	8.1	7.1	6.1	5.2
47	.14	.28	.43	.57	.71	.85	6.99	.14	.28	8.5	7.0	5.5	4.1	2.6
48	.13	.27	.40	.53	.67	.80	.93	.07	.20	8.0	6.0	4.0	52.0	40.0
49	.12	.25	.37	.50	.62	.75	.87	5.00	.12	7.5	4.9	2.4	49.9	37.3
74 50	8.12	16.23	24.35	32.46	40.58	48.69	56.81	64.93	73.04	486.9	973.9	1460.8	1947.8	2434.7
51	.11	.21	.32	.43	.54	.64	.75	.86	2.96	6.4	2.8	59.3	5.7	32.1
52	.10	.20	.30	.39	.49	.59	.69	.79	.88	5.9	1.8	7.7	3.6	29.5
53	.09	.18	.27	.36	.45	.54	.63	.72	.81	5.4	70.8	6.1	41.5	6.9
54	.08	.16	.24	.32	.40	.49	.57	.65	.73	4.9	69.7	4.6	39.4	4.3
74 55	8.07	16.14	24.22	32.29	40.36	48.43	56.51	64.58	72.65	484.3	968.7	1453.0	1937.3	2421.7
56	.06	.13	.19	.25	.32	.38	.44	.51	.57	3.8	7.6	51.4	5.2	19.1
57	.05	.11	.16	.22	.27	.33	.38	.44	.49	3.3	6.6	49.9	3.2	6.4
58	.05	.09	.14	.18	.23	.28	.32	.37	.41	2.8	5.5	8.3	31.1	3.8
59	.04	.07	.11	.15	.19	.22	.26	.30	.34	2.2	4.5	6.7	29.0	11.2
74 60	8.03	16.06	24.09	32.11	40.14	48.17	56.20	64.23	72.26	481.7	963.4	1445.2	1926.9	2408.6

Lat.		Latitude 74° to 75°—Meridional arcs.						Latitude 74°—Co-ordinates of curvature.			
		Value of 1''	Sums of seconds for middle latitude.		Value of 1'	Sums of minutes for middle latitude.		Longitude.		X	Y
°	'	*Meters.*	''	*Meters.*	*Meters.*	'	*Meters.*	°	'	*Meters.*	*Meters.*
74	00	31.004			1860.21						
	1	4	1	31.00	.21	1	1 860.2	0	1	513.0	0.1
	2	4	2	62.01	.22	2	3 720.4		2	1 026.0	0.3
	3	4	3	93.01	.22	3	5 580.6		3	1 539.0	0.6
	4	4	4	124.02	.22	4	7 440.9		4	2 052.0	1.1
74	05	31.004	5	155.02	1860.23	5	9 301.1	0	5	2 565.1	1.8
	6	4	6	186.03	.23	6	11 161.3		6	3 078.1	2.6
	7	4	7	217.03	.23	7	13 021.5		7	3 591.1	3.5
	8	4	8	248.04	.23	8	14 881.8		8	4 104.1	4.6
	9	4	9	279.04	.24	9	16 742.0		9	4 617.1	5.8
74	10	31.004	10	310.05	1860.24	10	18 602.3	0	10	5 130.1	7.2
	11	4	1	341.05	.24	1	20 462.5		15	7 695.1	16.1
	12	4	2	372.06	.25	2	22 322.7		20	10 260.1	28.7
	13	4	3	403.06	.25	3	24 183.0		25	12 825.1	44.8
	14	4	4	434.07	.25	4	26 043.2		30	15 390.1	64.5
74	15	31.004	15	465.07	1860.25	15	27 903.5	0	35	17 955.0	87.9
	16	4	6	496.08	.26	6	29 763.7		40	20 519.9	114.8
	17	4	7	527.08	.26	7	31 624.0		45	23 084.8	145.2
	18	4	8	558.09	.26	8	33 484.3		50	25 649.6	179.3
	19	4	9	589.09	.27	9	35 344.5		55	28 214.4	217.0
74	20	31.004	20	620.10	1860.27	20	37 204.8	1	00	30 779.1	258.2
	21	5	1	651.10	.27	1	39 065.1		05	33 343.8	303.0
	22	5	2	682.11	.27	2	40 925.3		10	35 908.4	351.4
	23	5	3	713.11	.28	3	42 785.6		15	38 472.9	403.4
	24	5	4	744.12	.28	4	44 645.9		20	41 037.3	459.0
74	25	31.005	25	775.12	1860.28	25	46 506.2	1	25	43 601.7	518.2
	26	5	6	806.13	.29	6	48 366.5		30	46 166.0	580.9
	27	5	7	837.13	.29	7	50 226.8		35	48 730.1	647.3
	28	5	8	868.14	.29	8	52 087.0		40	51 294.2	717.2
	29	5	9	899.14	.29	9	53 947.3		45	53 858.2	790.7
74	30	31.005	30	930.15	1860.30	30	55 807.6	1	50	56 422.1	867.8
	31	5	1	961.15	.30	1	57 667.9		55	58 985.9	948.5
	32	5	2	992.16	.30	2	59 528.2	2	00	61 550	1 033
	33	5	3	1 023.16	.31	3	61 388.5	3	00	92 303	2 324
	34	5	4	1 054.17	.31	4	63 248.8	4	00	123 030	4 130
74	35	31.005	35	1 085.17	1860.31	35	65 109.2	5	00	153 722	6 451
	36	5	6	1 116.18	.31	6	66 969.5	6	00	184 372	9 288
	37	5	7	1 147.18	.32	7	68 829.8	7	00	214 969	12 638
	38	5	8	1 178.19	.32	8	70 690.1	8	00	245 506	16 500
	39	5	9	1 209.19	.32	9	72 550.4	9	00	275 973	20 875
74	40	31.005	40	1 240.20	1860.33	40	74 410.8	10	00	306 364	25 760
	41	5	1	1 271.20	.33	1	76 271.1	11	00	336 667	31 154
	42	6	2	1 302.21	.33	2	78 131.4	12	00	366 876	37 056
	43	6	3	1 333.21	.33	3	79 991.7	13	00	396 982	43 464
	44	6	4	1 364.22	.34	4	81 852.1	14	00	426 976	50 376
74	45	31.006	45	1 395.22	1860.34	45	83 712.4	15	00	456 850	57 790
	46	6	6	1 426.23	.34	6	85 572.8	16	00	486 596	65 705
	47	6	7	1 457.23	.35	7	87 433.1	17	00	516 204	74 117
	48	6	8	1 488.24	.35	8	89 293.5	18	00	545 667	83 025
	49	6	9	1 519.24	.35	9	91 153.8	19	00	574 976	92 426
74	50	31.006	50	1 550.25	1860.35	50	93 014.2	20	00	604 124	102 317
	51	6	1	1 581.25	.36	1	94 874.5	21	00	633 102	112 696
	52	6	2	1 612.26	.36	2	96 734.9	22	00	661 901	123 559
	53	6	3	1 643.26	.36	3	98 595.2	23	00	690 514	134 904
	54	6	4	1 674.27	.37	4	100 455.6	24	00	718 933	146 728
74	55	31.006	55	1 705.27	1860.37	55	102 316.0	25	00	747 149	159 027
	56	6	6	1 736.28	.37	6	104 176.3	26	00	775 155	171 797
	57	6	7	1 767.28	.37	7	106 036.7	27	00	802 943	185 035
	58	6	8	1 798.29	.38	8	107 897.1	28	00	830 505	198 738
	59	6	9	1 829.29	.38	9	109 757.5	29	00	857 833	212 901
74	60	31.006	60	1 860.30	1860.38	60	111 617.9	30	00	884 920	227 520

Latitude 75° to 76°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
75 00	8.03	16.06	24.09	32.11	40.14	48.17	56.20	64.23	72.26	481.7	963.4	1445.2	1926.9	2408.6
1	.02	.04	.06	.08	.10	.12	.14	.16	.18	1.2	2.4	3.6	4.8	6.0
2	.01	.02	.03	.04	.06	.07	.08	.09	.10	0.7	1.4	2.0	2.7	03.4
3	8.00	6.01	4.01	2.01	40.01	8.02	6.02	4.02	2.02	80.2	60.3	40.5	20.6	400.8
4	7.99	5.99	3.98	1.98	39.97	7.96	5.96	3.95	1.95	79.6	59.3	38.9	18.5	398.2
75 05	7.99	15.97	23.96	31.94	39.92	47.91	55.89	63.88	71.87	479.1	958.2	1437.3	1916.4	2395.5
6	.98	.95	.93	.91	.88	.86	.83	.81	.79	8.6	7.2	5.8	4.3	2.9
7	.97	.94	.90	.87	.84	.81	.77	.74	.71	8.1	6.1	4.2	2.2	90.3
8	.96	.92	.88	.84	.80	.75	.71	.67	.63	7.5	5.1	2.6	10.2	87.7
9	.95	.90	.85	.80	.75	.70	.65	.60	.55	7.0	4.0	31.0	08.1	5.1
75 10	7.94	15.88	23.82	31.77	39.71	47.65	55.59	63.53	71.47	476.5	953.0	1429.5	1906.0	2382.5
11	.93	.87	.80	.73	.66	.60	.53	.46	.39	6.0	1.9	7.9	3.9	79.8
12	.92	.85	.77	.70	.62	.54	.47	.39	.32	5.4	50.9	6.3	901.8	7.2
13	.92	.83	.75	.66	.58	.49	.41	.32	.24	4.9	49.8	4.8	899.7	4.6
14	.91	.81	.72	.63	.53	.44	.35	.25	.16	4.4	8.8	3.2	7.6	2.0
75 15	7.90	15.80	23.69	31.59	39.49	47.39	55.29	63.18	71.08	473.9	947.8	1421.6	1895.5	2369.4
16	.89	.78	.67	.56	.45	.34	.22	.11	1.00	3.4	6.7	20.1	3.4	6.8
17	.88	.76	.64	.52	.40	.28	.16	3.04	0.92	2.8	5.7	18.5	91.3	4.1
18	.87	.74	.61	.49	.36	.23	.10	2.97	.85	2.3	4.6	6.9	89.2	61.5
19	.86	.73	.59	.45	.31	.18	5.04	.90	.77	1.8	3.6	5.3	7.1	58.9
75 20	7.85	15.71	23.56	31.42	39.27	47.13	54.98	62.83	70.69	471.3	942.5	1413.8	1885.0	2356.3
21	.85	.69	.54	.38	.23	.07	.92	.76	.61	0.7	1.5	2.2	2.9	3.7
22	.84	.67	.51	.35	.18	7.02	.86	.69	.53	70.2	40.4	10.6	80.8	51.1
23	.83	.66	.48	.31	.14	6.97	.80	.62	.45	69.7	39.4	09.1	78.8	48.4
24	.82	.64	.46	.28	.10	.92	.74	.55	.37	9.2	8.3	7.5	6.7	5.8
75 25	7.81	15.62	23.43	31.24	39.05	46.86	54.67	62.49	70.30	468.6	937.3	1405.9	1874.6	2343.2
26	.80	.60	.41	.21	9.01	.81	.61	.42	.22	8.1	6.2	4.3	2.5	40.6
27	.79	.59	.38	.17	8.97	.76	.55	.35	.14	7.6	5.2	2.8	70.4	38.0
28	.78	.57	.35	.14	.92	.71	.49	.28	70.06	7.1	4.1	401.2	68.3	5.3
29	.78	.55	.33	.10	.88	.65	.43	.21	69.98	6.5	3.1	399.6	6.2	2.7
75 30	7.77	15.53	23.30	31.07	38.84	46.60	54.37	62.14	69.90	466.0	932.0	1398.1	1864.1	2330.1
31	.76	.52	.27	.03	.79	.55	.31	.07	.82	5.5	31.0	6.5	62.0	27.5
32	.75	.50	.25	1.00	.75	.50	.25	2.00	.74	5.0	29.9	4.9	59.9	4.9
33	.74	.48	.22	0.96	.70	.44	.19	1.93	.67	4.4	8.9	3.3	7.8	22.2
34	.73	.46	.20	.93	.66	.39	.12	.86	.59	3.9	7.8	1.8	5.7	19.6
75 35	7.72	15.45	23.17	30.89	38.62	46.34	54.06	61.79	69.51	463.4	926.8	1390.2	1853.6	2317.0
36	.71	.43	.14	.86	.57	.29	4.00	.72	.43	2.9	5.8	88.6	51.5	4.4
37	.71	.41	.12	.82	.53	.24	3.94	.65	.35	2.4	4.7	7.1	49.4	11.8
38	.70	.39	.09	.79	.49	.18	.88	.58	.28	1.8	3.7	5.5	7.3	09.1
39	.69	.38	.07	.75	.44	.13	.82	.51	.20	1.3	2.6	3.9	5.2	6.5
75 40	7.68	15.36	23.04	30.72	38.40	46.08	53.76	61.44	69.12	460.8	921.6	1382.3	1843.1	2303.9
41	.67	.34	3.01	.68	.36	6.03	.70	.37	9.04	60.3	20.5	80.8	41.0	301.3
42	.66	.32	2.99	.65	.31	5.97	.64	.30	8.96	59.7	19.5	79.2	38.9	298.7
43	.65	.31	.96	.61	.27	.92	.57	.23	.88	9.2	8.4	7.6	6.8	6.0
44	.64	.29	.93	.58	.22	.87	.51	.16	.80	8.7	7.4	6.0	4.7	3.4
75 45	7.64	15.27	22.91	30.54	38.18	45.82	53.45	61.09	68.72	458.2	916.3	1374.5	1832.6	2290.8
46	.63	.25	.88	.51	.14	.76	.39	1.02	.65	7.6	5.3	2.9	30.5	88.2
47	.62	.24	.86	.47	.09	.71	.33	0.95	.57	7.1	4.2	71.3	28.4	5.5
48	.61	.22	.83	.44	.05	.66	.27	.88	.49	6.6	3.2	69.8	6.3	2.9
49	.60	.20	.80	.40	8.00	.61	.21	.81	.41	6.1	2.1	8.2	4.2	80.3
75 50	7.59	15.18	22.78	30.37	37.96	45.55	53.15	60.74	68.33	455.5	911.1	1366.6	1822.1	2277.7
51	.58	.17	.75	.33	.92	.50	.08	.67	.25	5.0	10.0	5.0	20.0	5.0
52	.57	.15	.72	.30	.87	.45	3.02	.60	.17	4.5	09.0	3.5	17.9	72.4
53	.57	.13	.70	.26	.83	.40	2.96	.53	.09	4.0	7.9	1.9	5.8	69.8
54	.56	.11	.67	.23	.79	.34	.90	.46	8.02	3.4	6.9	60.3	3.7	7.2
75 55	7.55	15.10	22.65	30.19	37.74	45.29	52.84	60.39	67.94	452.9	905.8	1358.7	1811.6	2264.5
56	.54	.08	.62	.16	.70	.24	.78	.32	.86	2.4	04.8	7.2	09.5	61.9
57	.53	.06	.59	.12	.65	.19	.72	.25	.78	1.9	03.7	5.6	7.4	59.3
58	.52	.04	.57	.09	.61	.13	.65	.18	.70	1.3	02.7	4.0	5.3	6.7
59	.51	.03	.54	.05	.57	.08	.59	.11	.62	0.8	01.6	2.4	3.2	4.0
75 60	7.50	15.01	22.51	30.02	37.52	45.03	52.53	60.04	67.54	450.3	900.6	1350.9	1801.1	2251.4

Lat.	Latitude 75° to 76°—Meridional arcs.						Latitude 75°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
75 00	31.006			1860.38					
1	6	1	31.01	.38	1	1 860.4	0 1	481.7	0.1
2	6	2	62.02	.39	2	3 720.8	2	963.4	0.3
3	6	3	93.02	.39	3	5 581.2	3	1 445.2	0.6
4	7	4	124.03	.39	4	7 441.5	4	1 926.9	1.1
75 05	31.007	5	155.04	1860.40	5	9 301.9	0 5	2 408.6	1.7
6	7	6	186.05	.40	6	11 162.3	6	2 890.3	2.4
7	7	7	217.05	.40	7	13 022.7	7	3 372.1	3.3
8	7	8	248.06	.40	8	14 883.1	8	3 853.8	4.3
9	7	9	279.07	.41	9	16 743.5	9	4 335.5	5.5
75 10	31.007	10	310.08	1860.41	10	18 604.0	0 10	4 817.2	6.8
11	7	1	341.08	.41	1	20 464.4	15	7 225.8	15.2
12	7	2	372.09	.41	2	22 324.8	20	9 634.4	27.1
13	7	3	403.10	.42	3	24 185.2	25	12 043.0	42.3
14	7	4	434.11	.42	4	26 045.6	30	14 451.5	60.9
75 15	31.007	15	465.12	1860.42	15	27 906.0	0 35	16 860.0	82.9
16	7	6	496.12	.43	6	29 766.5	40	19 268.5	108.3
17	7	7	527.13	.43	7	31 626.9	45	21 676.9	137.0
18	7	8	558.14	.43	8	33 487.3	50	24 085.3	169.2
19	7	9	589.15	.43	9	35 347.8	55	26 493.7	204.7
75 20	31.007	20	620.15	1860.44	20	37 208.2	1 00	28 902.0	243.6
21	7	1	651.16	.44	1	39 068.6	05	31 310.2	285.9
22	7	2	682.17	.44	2	40 929.1	10	33 718.4	331.6
23	7	3	713.18	.44	3	42 789.5	15	36 126.5	380.7
24	7	4	744.19	.45	4	44 650.0	20	38 534.5	433.1
75 25	31.007	25	775.19	1860.45	25	46 510.4	1 25	40 942.5	489.0
26	8	6	806.20	.45	6	48 370.9	30	43 350.4	548.1
27	8	7	837.21	.46	7	50 231.3	35	45 758.2	610.7
28	8	8	868.22	.46	8	52 091.8	40	48 165.9	676.7
29	8	9	899.22	.46	9	53 952.2	45	50 573.5	746.1
75 30	31.008	30	930.23	1860.46	30	55 812.7	1 50	52 981.0	818.8
31	8	1	961.24	.47	1	57 673.2	55	55 388.4	894.9
32	8	2	992.25	.47	2	59 533.6	2 00	57 796	975
33	8	3	1 023.25	.47	3	61 394.1	3 00	86 673	2 192
34	8	4	1 054.26	.47	4	63 254.6	4 00	115 526	3 897
75 35	31.008	35	1 085.27	1860.48	35	65 115.0	5 00	144 346	6 087
36	8	6	1 116.28	.48	6	66 975.5	6 00	173 124	8 763
37	8	7	1 147.29	.48	7	68 836.0	7 00	201 854	11 924
38	8	8	1 178.29	.48	8	70 696.5	8 00	230 526	15 569
39	8	9	1 209.30	.49	9	72 557.0	9 00	259 133	19 697
75 40	31.008	40	1 240.31	1860.49	40	74 417.5	10 00	287 666	24 306
41	8	1	1 271.32	.49	1	76 278.0	11 00	316 117	29 395
42	8	2	1 302.32	.50	2	78 138.4	12 00	344 479	34 964
43	8	3	1 333.33	.50	3	79 998.9	13 00	372 742	41 010
44	8	4	1 364.34	.50	4	81 859.4	14 00	400 900	47 531
75 45	31.008	45	1 395.35	1860.50	45	83 719.9	15 00	428 944	54 526
46	8	6	1 426.36	.51	6	85 580.5	16 00	456 866	61 993
47	8	7	1 457.36	.51	7	87 441.0	17 00	484 658	69 930
48	9	8	1 488.37	.51	8	89 301.5	18 00	512 312	78 334
49	9	9	1 519.38	.51	9	91 162.0	19 00	539 821	87 203
75 50	31.009	50	1 550.39	1860.52	50	93 022.5	20 00	567 176	96 534
51	9	1	1 581.39	.52	1	94 883.0	21 00	594 370	106 325
52	9	2	1 612.40	.52	2	96 743.6	22 00	621 395	116 574
53	9	3	1 643.41	.52	3	98 604.1	23 00	648 243	127 276
54	9	4	1 674.42	.53	4	100 464.6	24 00	674 907	138 430
75 55	31.009	55	1 705.42	1860.53	55	102 325.1	25 00	701 380	150 031
56	9	6	1 736.43	.53	6	104 185.7	26 00	727 653	162 077
57	9	7	1 767.44	.53	7	106 046.2	27 00	753 719	174 564
58	9	8	1 798.45	.54	8	107 906.7	28 00	779 571	187 489
59	9	9	1 829.46	.54	9	109 767.3	29 00	805 203	200 848
75 60	31.009	60	1 860.46	1860.54	60	111 627.8	30 00	830 604	214 637

Latitude 76° to 77°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
76 00	7.50	15.01	22.51	30.02	37.52	45.03	52.55	60.04	67.54	450.3	900.6	1350.9	1801.1	2251.4
1	.50	4.99	.49	29.98	.48	4.98	.47	59.97	.46	49.8	899.5	49.3	799.0	48.8
2	.49	.97	.46	.95	.44	.92	.41	.90	.38	9.2	8.5	7.7	6.9	6.2
3	.48	.96	.43	.91	.39	.87	.35	.83	.30	8.7	7.4	6.1	4.8	3.5
4	.47	.94	.41	.88	.35	.82	.29	.76	.23	8.2	6.4	4.5	2.7	40.9
76 05	7.46	14.92	22.38	29.84	37.30	44.77	52.23	59.69	67.15	447.7	895.3	1343.0	1790.6	2238.3
6	.45	.90	.36	.81	.26	.71	.16	.62	7.07	7.1	4.3	41.4	88.5	5.7
7	.44	.89	.33	.77	.22	.66	.10	.55	6.99	6.6	3.2	39.8	6.4	3.0
8	.43	.87	.30	.74	.17	.61	2.04	.48	.91	6.1	2.2	8.2	4.3	30.4
9	.43	.85	.28	.70	.13	.56	1.98	.41	.83	5.6	1.1	6.7	2.2	27.8
76 10	7.42	14.83	22.25	29.67	37.09	44.50	51.92	59.34	66.75	445.0	890.1	1335.1	1780.1	2225.2
11	.41	.82	.22	.63	.04	.45	.86	.27	.67	4.5	89.0	3.5	78.0	22.5
12	.40	.80	.20	.60	7.00	.40	.80	.20	.60	4.0	8.0	1.9	5.9	19.9
13	.39	.78	.17	.56	6.96	.35	.74	.13	.52	3.5	6.9	30.4	3.8	7.3
14	.38	.76	.15	.53	.91	.29	.67	9.06	.44	2.9	5.9	28.8	71.7	4.6
76 15	7.37	14.75	22.12	29.49	36.87	44.24	51.61	58.99	66.36	442.4	884.8	1327.2	1769.6	2212.0
16	.36	.73	.09	.46	.82	.19	.55	.92	.28	1.9	3.8	5.6	7.5	09.4
17	.36	.71	.07	.42	.78	.14	.49	.85	.20	1.4	2.7	4.1	5.4	6.8
18	.35	.69	.04	.39	.74	.08	.43	.78	.12	0.8	1.6	2.5	3.3	4.1
19	.34	.68	2.02	.35	.69	4.03	.37	.71	6.05	40.3	80.6	20.9	61.2	201.5
76 20	7.33	14.66	21.99	29.32	36.65	43.98	51.31	58.64	65.97	439.8	879.5	1319.3	1759.1	2198.9
21	.32	.64	.96	.28	.60	.92	.24	.57	.89	9.2	8.5	7.7	7.0	6.2
22	.31	.62	.94	.25	.56	.87	.18	.50	.81	8.7	7.4	6.2	4.9	3.6
23	.30	.61	.91	.21	.52	.82	.12	.43	.73	8.2	6.4	4.6	2.8	91.0
24	.29	.59	.88	.18	.47	.77	.06	.36	.65	7.7	5.3	3.0	50.7	88.4
76 25	7.29	14.57	21.86	29.14	36.43	43.71	51.00	58.29	65.57	437.1	874.3	1311.4	1748.6	2185.7
26	.28	.55	.83	.11	.39	.66	0.94	.22	.49	6.6	3.2	09.9	6.5	3.1
27	.27	.54	.81	.07	.34	.61	.88	.15	.42	6.1	2.2	8.3	4.4	80.5
28	.26	.52	.78	.04	.30	.56	.81	.08	.34	5.6	1.1	6.7	2.3	77.8
29	.25	.50	.75	9.00	.25	.50	.75	8.01	.26	5.0	70.1	5.1	40.2	5.2
76 30	7.24	14.48	21.73	28.97	36.21	43.45	50.69	57.94	65.18	434.5	869.0	1303.5	1738.1	2172.6
31	.23	.47	.70	.93	.17	.40	.63	.86	.10	4.0	8.0	2.0	5.9	69.9
32	.22	.45	.67	.90	.12	.35	.57	.79	5.02	3.5	6.9	300.4	3.8	7.3
33	.22	.43	.65	.86	.08	.29	.51	.73	4.94	2.9	5.9	298.8	31.7	4.7
34	.21	.41	.62	.83	6.03	.24	.45	.65	.86	2.4	4.8	7.2	29.6	62.0
76 35	7.20	14.40	21.59	28.79	35.99	43.19	50.39	57.58	64.78	431.9	863.8	1295.6	1727.5	2159.4
36	.19	.38	.57	.76	.95	.14	.32	.51	.70	1.4	2.7	4.1	5.4	6.8
37	.18	.36	.54	.72	.90	.08	.26	.44	.62	0.8	1.7	2.5	3.3	4.1
38	.17	.34	.51	.69	.86	3.03	.20	.37	.55	30.3	60.6	90.9	21.2	51.5
39	.16	.33	.49	.65	.81	2.98	.14	.30	.47	29.8	59.6	89.3	19.1	48.9
76 40	7.15	14.31	21.46	28.62	35.77	42.92	50.08	57.23	64.39	429.2	858.5	1287.7	1717.0	2146.2
41	.15	.29	.44	.58	.73	.87	50.02	.16	.31	8.7	7.4	6.2	4.9	3.6
42	.14	.27	.41	.55	.68	.82	49.96	.09	.23	8.2	6.4	4.6	2.8	41.0
43	.13	.26	.38	.51	.64	.77	.89	7.02	.15	7.7	5.3	3.0	10.7	38.3
44	.12	.24	.36	.48	.59	.71	.83	6.95	4.07	7.1	4.3	81.4	08.6	5.7
76 45	7.11	14.22	21.33	28.44	35.55	42.66	49.77	56.88	63.99	426.6	853.2	1279.8	1706.5	2133.1
46	.10	.20	.30	.41	.51	.61	.71	.81	.91	6.1	2.2	8.3	4.5	30.4
47	.09	.19	.28	.37	.46	.56	.65	.74	.83	5.6	1.1	6.7	2.2	27.8
48	.08	.17	.25	.34	.42	.50	.59	.67	.76	5.0	50.1	5.1	700.1	5.2
49	.08	.15	.23	.30	.37	.45	.52	.60	.68	4.5	49.0	3.5	698.0	22.5
76 50	7.07	14.13	21.20	28.27	35.33	42.40	49.46	56.53	63.60	424.0	848.0	1271.9	1695.9	2119.9
51	.06	.12	.17	.23	.29	.35	.40	.46	.52	3.5	6.9	70.4	3.8	7.3
52	.05	.10	.15	.20	.24	.29	.34	.39	.44	2.9	5.9	68.8	91.7	4.6
53	.04	.08	.12	.16	.20	.24	.28	.32	.36	2.4	4.8	7.2	89.6	12.0
54	.03	.06	.09	.13	.16	.19	.22	.25	.28	1.9	3.7	5.6	7.5	09.4
76 55	7.02	14.04	21.07	28.09	35.11	42.13	49.16	56.18	63.20	421.3	842.7	1264.0	1685.4	2106.7
56	.01	.03	.04	.05	.07	.08	.09	.11	.12	0.8	1.6	2.5	3.3	4.1
57	.01	4.01	1.02	8.02	5.02	2.03	9.03	6.04	3.05	20.3	40.6	60.9	81.2	101.5
58	7.00	3.99	0.99	7.98	4.98	1.98	8.97	5.97	2.97	19.8	39.5	59.3	79.1	098.8
59	6.99	.97	.96	.95	.94	.92	.91	.90	.89	9.2	8.5	7.7	6.9	6.2
76 60	6.98	13.96	20.94	27.91	34.89	41.87	48.85	55.83	62.81	418.7	837.4	1256.1	1674.8	2093.5

Lat.		Latitude 76° to 77°—Meridional arcs.						Latitude 76°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
76	00	31.009			1860.54						
	1	9	1	31.01	.55	1	1 860.5	0	1	450.3	0.1
	2	9	2	62.02	.55	2	3 721.1		2	900.6	0.3
	3	9	3	93.03	.55	3	5 581.6		3	1 350.8	0.6
	4	9	4	124.04	.55	4	7 442.2		4	1 801.1	1.0
76	05	31.009	5	155.05	1860.56	5	9 302.7	0	5	2 251.4	1.6
	6	9	6	186.06	.56	6	11 163.3		6	2 701.7	2.3
	7	9	7	217.07	.56	7	13 023.9		7	3 152.0	3.1
	8	9	8	248.08	.56	8	14 884.4		8	3 602.3	4.1
	9	9	9	279.09	.57	9	16 745.0		9	4 052.6	5.1
76	10	31.009	10	310.10	1860.57	10	18 605.6	0	10	4 502.8	6.4
	11	10	1	341.11	.57	1	20 466.1		15	6 754.3	14.3
	12	10	2	372.12	.57	2	22 326.7		20	9 005.7	25.4
	13	0	3	403.13	.58	3	24 187.3		25	11 257.1	39.7
	14	0	4	434.14	.58	4	26 047.8		30	13 508.4	57.2
76	15	31.010	15	465.15	1860.58	15	27 908.4	0	35	15 759.7	77.8
	16	0	6	496.17	.58	6	29 769.0		40	18 011.0	101.7
	17	0	7	527.18	.59	7	31 629.6		45	20 262.3	128.7
	18	0	8	558.19	.59	8	33 490.2		50	22 513.5	158.9
	19	0	9	589.20	.59	9	35 350.8		55	24 764.7	192.2
76	20	31.010	20	620.21	1860.59	20	37 211.4	1	00	27 015.8	228.8
	21	0	1	651.22	.60	1	39 072.0		05	29 266.9	268.5
	22	0	2	682.23	.60	2	40 932.6		10	31 517.9	311.4
	23	0	3	713.24	.60	3	42 793.2		15	33 768.9	357.4
	24	0	4	744.25	.60	4	44 653.8		20	36 019.8	406.7
76	25	31.010	25	775.26	1860.61	25	46 514.4	1	25	38 270.6	459.1
	26	0	6	806.27	.61	6	48 375.0		30	40 521.3	514.7
	27	0	7	837.28	.61	7	50 235.6		35	42 772.0	573.5
	28	0	8	868.29	.61	8	52 096.2		40	45 022.6	635.4
	29	0	9	899.30	.62	9	53 956.8		45	47 273.1	700.5
76	30	31.010	30	930.31	1860.62	30	55 817.4	1	50	49 523.5	768.8
	31	0	1	961.32	.62	1	57 678.1		55	51 773.8	840.3
	32	0	2	992.33	.62	2	59 538.7	2	00	54 024	915
	33	0	3	1 023.34	.63	3	61 399.3	3	00	81 017	2 058
	34	0	4	1 054.35	.63	4	63 259.9	4	00	107 986	3 659
76	35	31.011	35	1 085.36	1860.63	35	65 120.6	5	00	134 924	5 716
	36	1	6	1 116.37	.63	6	66 981.2	6	00	161 824	8 228
	37	1	7	1 147.38	.64	7	68 841.8	7	00	188 677	11 196
	38	1	8	1 178.39	.64	8	70 702.5	8	00	215 477	14 619
	39	1	9	1 209.40	.64	9	72 563.1	9	00	242 214	18 494
76	40	31.011	40	1 240.41	1860.64	40	74 423.8	10	00	268 882	22 822
	41	1	1	1 271.42	.65	1	76 284.4	11	00	295 473	27 601
	42	1	2	1 302.43	.65	2	78 145.1	12	00	321 979	32 829
	43	1	3	1 333.44	.65	3	80 005.7	13	00	348 393	38 505
	44	1	4	1 364.45	.65	4	81 866.4	14	00	374 706	44 628
76	45	31.011	45	1 395.46	1860.66	45	83 727.0	15	00	400 913	51 196
	46	1	6	1 426.47	.66	6	85 587.7	16	00	427 004	58 207
	47	1	7	1 457.49	.66	7	87 448.3	17	00	452 973	65 658
	48	1	8	1 488.50	.66	8	89 309.0	18	00	478 812	73 547
	49	1	9	1 519.51	.67	9	91 169.7	19	00	504 514	81 874
76	50	31.011	50	1 550.52	1860.67	50	93 030.3	20	00	530 071	90 635
	51	1	1	1 581.53	.67	1	94 891.0	21	00	555 476	99 827
	52	1	2	1 612.54	.67	2	96 751.7	22	00	580 722	109 448
	53	1	3	1 643.55	.68	3	98 612.3	23	00	605 801	119 495
	54	[illegible]	4	1 674.56	.68	4	100 473.0	24	00	630 706	129 965
76	55	31.011	55	1 705.57	1860.68	55	102 333.7	25	00	655 431	140 856
	56	1	6	1 736.58	.68	6	104 194.4	26	00	679 967	152 163
	57	1	7	1 767.59	.69	7	106 055.1	27	00	704 309	163 885
	58	1	8	1 798.60	.69	8	107 915.8	28	00	728 449	176 017
	59	2	9	1 829.61	.69	9	109 776.5	29	00	752 379	188 556
76	60	31.012	60	1 860.62	1860.69	60	111 637.1	30	00	776 094	201 498

Latitude 77° to 78°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
77 00	6.98	13.96	20.94	27.91	34.89	41.87	48.85	55.83	62.81	418.7	837.4	1256.1	1674.8	2093.5
1	.97	.94	.91	.88	.85	.82	.79	.76	.73	8.2	6.4	4.5	2.7	90.9
2	.96	.92	.86	.84	.80	.77	.73	.69	.65	7.7	5.3	3.0	70.6	88.3
3	.95	.90	.88	.81	.76	.71	.66	.62	.57	7.1	4.3	51.4	68.5	5.6
4	.94	.89	.83	.77	.72	.66	.60	.55	.49	6.6	3.2	49.8	6.4	3.0
77 05	6.94	13.87	20.80	27.74	34.67	41.61	48.54	55.48	62.41	416.1	832.1	1248.2	1664.3	2080.4
6	.93	.85	.78	.70	.63	.55	.48	.40	.33	5.5	1.1	6.6	2.2	77.7
7	.92	.83	.75	.67	.58	.50	.42	.34	.25	5.0	30.0	5.0	60.1	5.1
8	.91	.82	.72	.63	.54	.45	.36	.26	.17	4.5	29.0	3.5	58.0	72.4
9	.90	.80	.70	.60	.50	.40	.29	.19	.09	4.0	7.9	1.9	5.8	69.8
77 10	6.89	13.78	20.67	27.56	34.45	41.34	48.23	55.12	62.01	413.4	826.9	1240.3	1653.7	2067.2
11	.88	.76	.64	.53	.41	.29	.17	5.05	1.94	2.9	5.8	38.7	51.6	4.5
12	.87	.75	.62	.49	.36	.24	.11	4.98	.86	2.4	4.8	7.1	49.5	61.9
13	.86	.73	.59	.46	.32	.18	8.05	.91	.78	1.8	3.7	5.5	7.4	59.2
14	.85	.71	.57	.42	.28	.13	7.99	.84	.70	1.3	2.6	4.0	5.3	6.6
77 15	6.85	13.69	20.54	27.39	34.23	41.08	47.93	54.77	61.62	410.8	821.6	1232.4	1643.2	2054.0
16	.84	.68	.51	.35	.19	1.03	.86	.70	.54	10.3	20.5	30.8	41.1	51.3
17	.83	.66	.49	.32	.14	0.97	.80	.63	.46	09.7	19.5	29.2	38.9	48.7
18	.82	.64	.46	.28	.10	.92	.74	.56	.38	9.2	8.4	7.6	6.8	6.0
19	.81	.62	.43	.25	.06	.87	.68	.49	.30	8.7	7.4	6.0	4.7	3.4
77 20	6.80	13.61	20.41	27.21	34.01	40.82	47.62	54.42	61.22	408.2	816.3	1224.5	1632.6	2040.8
21	.79	.59	.38	.17	3.97	.76	.56	.35	.14	7.6	5.2	2.9	30.5	38.1
22	.78	.57	.36	.14	.92	.71	.50	.28	1.06	7.1	4.2	21.3	28.4	5.5
23	.77	.55	.33	.10	.88	.66	.43	.21	0.98	6.6	3.1	19.7	6.3	2.8
24	.77	.53	.30	.07	.84	.60	.37	.14	.91	6.0	2.1	8.1	4.2	30.2
77 25	6.76	13.52	20.28	27.03	33.79	40.55	47.31	54.07	60.83	405.5	811.0	1216.5	1622.1	2027.6
26	.75	.50	.25	7.00	.75	.50	.25	4.00	.75	5.0	10.0	5.0	19.9	4.9
27	.74	.48	.22	6.96	.70	.45	.19	3.93	.67	4.5	08.9	3.4	7.8	22.3
28	.73	.46	.20	.95	.66	.39	.12	.86	.59	3.9	7.9	1.8	5.7	19.6
29	.72	.45	.17	.89	.62	.34	.06	.79	.51	3.4	6.8	10.2	3.6	7.0
77 30	6.71	13.43	20.14	26.86	33.57	40.29	47.00	53.72	60.43	402.9	805.7	1208.6	1611.5	2014.4
31	.71	.41	.12	.82	.53	.23	6.94	.65	.35	2.3	4.7	7.0	09.4	11.7
32	.70	.39	.09	.79	.48	.18	.88	.58	.27	1.8	3.6	5.4	7.3	09.1
33	.69	.38	.06	.75	.44	.13	.82	.50	.19	1.3	2.6	3.9	5.1	6.4
34	.68	.36	.04	.72	.40	.08	.75	.43	.11	0.8	1.5	2.3	3.0	3.8
77 35	6.67	13.34	20.01	26.68	33.35	40.02	46.69	53.36	60.03	400.2	800.5	1200.7	1600.9	2001.1
36	.66	.32	19.98	.65	.31	39.97	.63	.29	59.96	399.7	799.4	199.1	598.8	1998.5
37	.65	.31	.96	.61	.26	.92	.57	.22	.88	9.2	8.3	7.5	6.7	5.9
38	.64	.29	.93	.58	.22	.86	.51	.15	.80	8.6	7.3	5.9	4.6	3.2
39	.64	.27	.91	.54	.18	.81	.45	.08	.72	8.1	6.2	4.3	2.5	90.6
77 40	6.63	13.25	19.88	26.51	33.13	39.76	46.38	53.01	59.64	397.6	795.2	1192.8	1590.3	1987.9
41	.62	.24	.85	.47	.09	.71	.32	2.94	.56	7.1	4.1	91.2	88.2	5.3
42	.61	.22	.83	.43	.04	.65	.26	.87	.48	6.5	3.0	89.6	6.1	2.6
43	.60	.20	.80	.40	3.00	.60	.20	.80	.40	6.0	2.0	8.0	4.0	80.0
44	.59	.18	.77	.36	2.95	.55	.14	.73	.32	5.5	90.9	6.4	81.9	77.3
77 45	6.58	13.16	19.75	26.33	32.91	39.49	46.07	52.66	59.24	394.9	789.9	1184.8	1579.8	1974.7
46	.57	.15	.72	.29	.87	.44	6.01	.59	.16	4.4	8.8	3.2	7.6	72.1
47	.56	.13	.69	.26	.82	.39	5.95	.52	.08	3.9	7.8	1.6	5.5	69.4
48	.56	.11	.66	.22	.78	.34	.89	.45	9.00	3.4	6.7	80.1	3.4	6.8
49	.55	.09	.64	.19	.73	.28	.83	.38	8.92	2.8	5.6	78.5	71.3	4.1
77 50	6.54	13.08	19.61	26.15	32.69	39.23	45.77	52.31	58.84	392.3	784.6	1176.9	1569.2	1961.5
51	.53	.06	.59	.12	.65	.18	.71	.24	.76	1.8	3.5	5.3	7.1	58.8
52	.52	.04	.56	.08	.60	.12	.64	.17	.68	1.2	2.5	3.7	4.9	6.2
53	.51	.02	.53	.05	.56	.07	.58	.09	.60	0.7	1.4	2.1	2.8	3.5
54	.50	3.01	.51	6.01	.51	9.02	.52	2.02	.53	90.2	80.4	70.5	60.7	50.9
77 55	6.49	12.99	19.48	25.98	32.47	38.96	45.46	51.95	58.45	389.6	779.3	1168.9	1558.6	1948.2
56	.49	.97	.46	.94	.43	.91	.40	.88	.37	9.1	8.2	7.4	6.5	5.6
57	.48	.95	.43	.91	.38	.86	.34	.81	.29	8.6	7.2	5.8	4.4	3.0
58	.47	.94	.40	.87	.34	.81	.27	.74	.21	8.1	6.1	4.2	2.2	40.3
59	.46	.92	.38	.84	.29	.75	.21	.67	.13	7.5	5.1	2.6	50.1	37.7
77 60	6.45	12.90	19.35	25.80	32.25	38.70	45.15	51.60	58.05	387.0	774.0	1161.0	1548.0	1935.0

Lat.		Latitude 77° to 78°—Meridional arcs.						Latitude 77°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
77	00	31.012			1860.69						
	1	2	1	31.01	.70	1	1 860.7	0	1	418.7	0.1
	2	2	2	62.03	.70	2	3 721.4		2	837.4	0.2
	3	2	3	93.04	.70	3	5 582.1		3	1 256.1	0.5
	4	2	4	124.05	.70	4	7 442.8		4	1 674.8	0.9
77	05	31.012	5	155.06	1860.71	5	9 303.5	0	5	2 093.5	1.5
	6	2	6	186.08	.71	6	11 164.2		6	2 512.3	2.1
	7	2	7	217.09	.71	7	13 024.9		7	2 931.0	2.9
	8	2	8	248.10	.71	8	14 885.6		8	3 349.7	3.8
	9	2	9	279.11	.71	9	16 746.3		9	3 768.4	4.8
77	10	31.012	10	310.13	1860.72	10	18 607.1	0	10	4 187.1	5.9
	11	2	1	341.14	.72	1	20 467.8		15	6 280.6	13.4
	12	2	2	372.15	.72	2	22 328.5		20	8 374.1	23.7
	13	2	3	403.17	.72	3	24 189.2		25	10 467.6	37.1
	14	2	4	434.18	.73	4	26 049.9		30	12 561.1	53.4
77	15	31.012	15	465.19	1860.73	15	27 910.7	0	35	14 654.6	72.7
	16	2	6	496.20	.73	6	29 771.4		40	16 748.0	94.9
	17	2	7	527.22	.73	7	31 632.1		45	18 841.4	120.2
	18	2	8	558.23	.74	8	33 492.9		50	20 934.8	148.3
	19	2	9	589.24	.74	9	35 353.6		55	23 028.1	179.5
77	20	31.012	20	620.25	1860.74	20	37 214.3	1	00	25 121.4	213.6
	21	2	1	651.27	.74	1	39 075.1		05	27 214.6	250.7
	22	2	2	682.28	.75	2	40 935.8		10	29 307.7	290.7
	23	2	3	713.29	.75	3	42 796.6		15	31 400.8	333.8
	24	3	4	744.31	.75	4	44 657.3		20	33 493.9	379.7
77	25	31.013	25	775.32	1860.75	25	46 518.1	1	25	35 586.9	428.7
	26	3	6	806.33	.76	6	48 378.8		30	37 679.8	480.6
	27	3	7	837.34	.76	7	50 239.6		35	39 772.6	535.5
	28	3	8	868.36	.76	8	52 100.3		40	41 865.3	593.3
	29	3	9	899.37	.76	9	53 961.1		45	43 958.0	654.1
77	30	31.013	30	930.38	1860.76	30	55 821.9	1	50	46 050.6	717.9
	31	3	1	961.40	.77	1	57 682.6		55	48 143.0	784.7
	32	3	2	992.41	.77	2	59 543.4	2	00	50 235	854
	33	3	3	1 023.42	.77	3	61 404.2	3	00	75 335	1 922
	34	3	4	1 054.43	.77	4	63 265.0	4	00	100 413	3 417
77	35	31.013	35	1 085.45	1860.78	35	65 125.7	5	00	125 462	5 337
	36	3	6	1 116.46	.78	6	66 986.5	6	00	150 474	7 684
	37	3	7	1 147.47	.78	7	68 847.3	7	00	175 443	10 455
	38	3	8	1 178.48	.78	8	70 708.1	8	00	200 361	13 650
	39	3	9	1 209.50	.79	9	72 568.9	9	00	225 221	17 269
77	40	31.013	40	1 240.51	1860.79	40	74 429.6	10	00	250 016	21 310
	41	3	1	1 271.52	.79	1	76 290.4	11	00	274 739	25 772
	42	3	2	1 302.54	.79	2	78 151.2	12	00	299 383	30 654
	43	3	3	1 333.55	.79	3	80 012.0	13	00	323 939	35 954
	44	3	4	1 364.56	.80	4	81 872.8	14	00	348 403	41 671
77	45	31.013	45	1 395.57	1860.80	45	83 733.6	15	00	372 765	47 804
	46	3	6	1 426.59	.80	6	85 594.4	16	00	397 019	54 349
	47	3	7	1 457.60	.80	7	87 455.2	17	00	421 159	61 306
	48	3	8	1 488.61	.81	8	89 316.0	18	00	445 177	68 673
	49	3	9	1 519.62	.81	9	91 176.8	19	00	469 066	76 447
77	50	31.014	50	1 550.64	1860.81	50	93 037.6	20	00	492 820	84 626
	51	4	1	1 581.65	.81	1	94 898.5	21	00	516 431	93 208
	52	4	2	1 612.66	.82	2	96 759.3	22	00	539 892	102 190
	53	4	3	1 643.68	.82	3	98 620.1	23	00	563 198	111 570
	54	4	4	1 674.69	.82	4	100 480.9	24	00	586 341	121 345
77	55	31.014	55	1 705.70	1860.82	55	102 341.7	25	00	609 314	131 512
	56	4	6	1 736.71	.82	6	104 202.5	26	00	632 111	142 068
	57	4	7	1 767.73	.83	7	106 063.4	27	00	654 725	153 010
	58	4	8	1 798.74	.83	8	107 924.2	28	00	677 149	164 335
	59	4	9	1 829.75	.83	9	109 785.0	29	00	699 378	176 040
77	60	31.014	60	1 860.76	1860.83	60	111 645.9	30	00	721 405	188 121

Latitude 78° to 79°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
78 00	6.45	12.90	19.35	25.80	32.25	38.70	45.15	51.60	58.05	387.0	774.0	1161.0	1548.0	1935.0
1	.44	.88	.32	.77	.21	.65	.09	.53	7.97	6.5	2.9	59.4	5.9	32.4
2	.43	.86	.30	.73	.16	.59	5.03	.46	.89	5.9	1.9	7.8	3.8	29.7
3	.42	.85	.27	.69	.12	.54	4.96	.39	.81	5.4	70.8	6.2	41.7	7.1
4	.41	.83	.24	.66	.07	.49	.90	.32	.73	4.9	69.8	4.7	39.5	4.4
78 05	6.41	12.81	19.22	25.62	32.03	38.44	44.84	51.24	57.65	384.4	768.7	1153.1	1537.4	1921.8
6	.40	.79	.19	.59	1.99	.38	.78	.18	.57	3.8	7.6	51.5	5.3	19.1
7	.39	.78	.17	.55	.94	.33	.72	.11	.50	3.3	6.6	49.9	3.2	6.5
8	.38	.76	.14	.52	.90	.28	.65	1.03	.42	2.8	5.5	8.3	31.1	3.8
9	.37	.74	.11	.48	.85	.22	.59	0.96	.34	2.2	4.5	6.7	28.9	11.2
78 10	6.36	12.72	19.09	25.45	31.81	38.17	44.53	50.89	57.26	381.7	763.4	1145.1	1526.8	1908.5
11	.35	.71	.06	.41	.77	.12	.47	.82	.18	1.2	2.4	3.5	4.7	5.9
12	.34	.69	.03	.38	.72	.06	.41	.75	.10	0.6	1.3	1.9	2.6	3.2
13	.34	.67	9.01	.34	.68	8.01	.34	.68	7.02	80.1	60.2	40.4	20.5	900.6
14	.33	.65	8.98	.31	.63	7.96	.28	.61	6.94	79.6	59.2	38.8	18.3	897.9
78 15	6.32	12.64	18.95	25.27	31.59	37.91	44.22	50.54	56.86	379.1	758.1	1137.2	1516.2	1895.3
16	.31	.62	.93	.23	.54	.85	.16	.47	.78	8.5	7.1	5.6	4.1	2.6
17	.30	.60	.90	.20	.50	.80	.10	.40	.70	8.0	6.0	4.0	12.0	90.0
18	.29	.58	.87	.16	.46	.75	4.04	.33	.62	7.5	4.9	2.4	09.9	87.3
19	.28	.56	.85	.13	.41	.69	3.97	.26	.54	6.9	3.9	30.8	7.7	4.7
78 20	6.27	12.55	18.82	25.09	31.37	37.64	43.91	50.19	56.46	376.4	752.8	1129.2	1505.6	1882.0
21	.26	.53	.79	.06	.32	.59	.85	.12	.38	5.9	1.8	7.6	3.5	79.4
22	.26	.51	.77	5.02	.28	.53	.79	50.05	.30	5.3	50.7	6.0	501.4	6.7
23	.25	.49	.74	4.99	.24	.48	.73	49.98	.22	4.8	49.6	4.4	499.3	4.1
24	.24	.48	.71	.95	.19	.43	.67	.90	.14	4.3	8.6	2.9	7.1	71.4
78 25	6.23	12.46	18.69	24.92	31.15	37.38	43.60	49.83	56.06	373.8	747.5	1121.3	1495.0	1868.8
26	.22	.44	.66	.88	.10	.32	.54	.76	5.98	3.2	6.5	19.7	2.9	6.1
27	.21	.42	.64	.85	.06	.27	.48	.69	.91	2.7	5.4	8.1	90.8	3.5
28	.20	.41	.61	.81	1.01	.22	.42	.62	.83	2.2	4.3	6.5	88.7	60.8
29	.19	.39	.58	.78	0.97	.16	.36	.55	.75	1.6	3.3	4.9	6.5	58.2
78 30	6.19	12.37	18.56	24.74	30.93	37.11	43.30	49.48	55.67	371.1	742.2	1113.3	1484.4	1855.5
31	.18	.35	.53	.71	.88	.06	.23	.41	.59	0.6	1.1	1.7	2.3	2.9
32	.17	.33	.50	.67	.84	7.00	.17	.34	.51	70.0	40.1	10.1	80.2	50.2
33	.16	.32	.48	.63	.79	6.95	.11	.27	.43	69.5	39.0	08.5	78.0	47.6
34	.15	.30	.45	.60	.75	.90	3.05	.20	.35	9.0	8.0	6.9	5.9	4.9
78 35	6.14	12.28	18.42	24.56	30.71	36.85	42.99	49.13	55.27	368.5	736.9	1105.4	1473.8	1842.3
36	.13	.26	.40	.53	.66	.79	.93	9.06	.19	7.9	5.8	3.8	71.7	39.6
37	.12	.25	.37	.49	.62	.74	.86	8.98	.11	7.4	4.8	2.2	69.6	6.9
38	.11	.23	.34	.46	.57	.69	.80	.91	5.03	6.9	3.7	100.6	7.4	4.3
39	.11	.21	.32	.42	.53	.63	.74	.84	4.95	6.3	2.7	099.0	5.3	31.6
78 40	6.10	12.19	18.29	24.39	30.48	36.58	42.68	48.77	54.87	365.8	731.6	1097.4	1463.2	1829.0
41	.09	.17	.26	.35	.44	.53	.62	.70	.79	5.3	30.5	5.8	61.1	6.3
42	.08	.16	.24	.32	.39	.47	.56	.63	.71	4.7	29.5	4.2	58.9	3.7
43	.07	.14	.21	.28	.35	.42	.49	.56	.63	4.2	8.4	2.6	6.8	21.0
44	.06	.12	.18	.25	.31	.37	.43	.49	.55	3.7	7.3	91.0	4.7	18.4
78 45	6.05	12.10	18.16	24.21	30.26	36.31	42.37	48.42	54.47	363.1	726.3	1089.4	1452.6	1815.7
46	.04	.09	.13	.17	.22	.26	.31	.35	.39	2.6	5.2	7.8	50.4	3.1
47	.03	.07	.10	.14	.17	.21	.24	.28	.31	2.1	4.2	6.2	48.3	10.4
48	.03	.05	.08	.10	.13	.16	.18	.21	.23	1.6	3.1	4.7	6.2	07.8
49	.02	.03	.05	.07	.08	.10	.12	.14	.15	1.0	2.0	3.1	4.1	5.1
78 50	6.01	12.02	18.02	24.03	30.04	36.05	42.06	48.06	54.07	360.5	721.0	1081.5	1442.0	1802.4
51	6.00	2.00	8.00	4.00	30.00	6.00	2.00	7.99	3.99	60.0	19.9	79.9	39.8	799.8
52	5.99	1.98	7.97	3.96	29.95	5.94	1.93	.92	.91	59.4	8.9	8.3	7.7	7.1
53	.98	.96	.94	.93	.91	.89	.87	.85	.83	8.9	7.8	6.7	5.6	4.5
54	.97	.95	.92	.89	.86	.84	.81	.78	.75	8.4	6.7	5.1	3.5	91.8
78 55	5.96	11.93	17.89	23.86	29.82	35.78	41.75	47.71	53.68	357.8	715.7	1073.5	1431.3	1789.2
56	.96	.91	.86	.82	.78	.73	.69	.64	.60	7.3	4.6	1.9	29.2	6.5
57	.95	.89	.84	.78	.73	.68	.62	.57	.52	6.8	3.5	70.3	7.1	3.9
58	.94	.87	.81	.75	.69	.62	.56	.50	.44	6.2	2.5	68.7	5.0	81.2
59	.93	.86	.79	.71	.64	.57	.50	.43	.36	5.7	1.4	7.1	2.8	78.5
78 60	5.92	11.84	17.76	23.68	29.60	35.52	41.44	47.36	53.28	355.2	710.4	1065.5	1420.7	1775.9

Lat.	Latitude 78° to 79°—Meridional arcs.						Latitude 78°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
78 00	31.014			1860.83					
1	4	1	31.01	.84	1	1 860.8	0 1	387.0	0.1
2	4	2	62.03	.84	2	3 721.7	2	774.0	0.2
3	4	3	93.04	.84	3	5 582.5	3	1 161.0	0.5
4	4	4	124.06	.84	4	7 443.4	4	1 548.0	0.9
78 05	31.014	5	155.07	1860.84	5	9 304.2	0 5	1 935.0	1.4
6	4	6	186.09	.85	6	11 165.0	6	2 322.0	2.0
7	4	7	217.10	.85	7	13 025.9	7	2 709.0	2.7
8	4	8	248.12	.85	8	14 886.7	8	3 096.0	3.5
9	4	9	279.13	.85	9	16 747.6	9	3 483.0	4.5
78 10	31.014	10	310.15	1860.86	10	18 608.4	0 10	3 870.0	5.5
11	4	1	341.16	.86	1	20 469.3	15	5 805.0	12.4
12	4	2	372.18	.86	2	22 330.2	20	7 740.0	22.0
13	4	3	403.19	.86	3	24 191.0	25	9 675.0	34.4
14	4	4	434.21	.86	4	26 051.9	30	11 610.0	49.6
78 15	31.014	15	465.22	1860.87	15	27 912.8	0 35	13 544.9	67.4
16	4	6	496.24	.87	6	29 773.6	40	15 479.8	88.1
17	5	7	527.25	.87	7	31 634.5	45	17 414.7	111.5
18	5	8	558.27	.87	8	33 495.4	50	19 349.5	137.6
19	5	9	589.28	.88	9	35 356.2	55	21 284.3	166.5
78 20	31.015	20	620.30	1860.88	20	37 217.1	1 00	23 219.1	198.2
21	5	1	651.31	.88	1	39 078.0	05	25 153.8	232.6
22	5	2	682.33	.88	2	40 938.9	10	27 088.4	269.8
23	5	3	713.34	.88	3	42 799.8	15	29 023.0	309.7
24	5	4	744.36	.89	4	44 660.6	20	30 957.6	352.4
78 25	31.015	25	775.37	1860.89	25	46 521.5	1 25	32 892.1	397.8
26	5	6	806.39	.89	6	48 382.4	30	34 826.5	445.9
27	5	7	837.40	.89	7	50 243.3	35	36 760.8	496.9
28	5	8	868.42	.90	8	52 104.2	40	38 695.1	550.5
29	5	9	899.43	.90	9	53 965.1	45	40 629.3	606.9
78 30	31.015	30	930.45	1860.90	30	55 826.0	1 50	42 563.4	666,1
31	5	1	961.46	.90	1	57 686.9	55	44 497.4	728.1
32	5	2	992.48	.90	2	59 547.8	2 00	46 431	793
33	5	3	1 023.49	.91	3	61 408.7	3 00	69 630	1 784
34	5	4	1 054.51	.91	4	63 269.6	4 00	92 809	3 170
78 35	31.015	35	1 085.52	1860.91	35	65 130.5	5 00	115 960	4 952
36	5	6	1 116.54	.91	6	66 991.4	6 00	139 078	7 129
37	5	7	1 147.55	.91	7	68 852.4	7 00	162 155	9 701
38	5	8	1 178.57	.92	8	70 713.3	8 00	185 185	12 665
39	5	9	1 209.58	.92	9	72 574.2	9 00	208 160	16 023
78 40	31.015	40	1 240.60	1860.92	40	74 435.1	10 00	231 076	19 773
41	5	1	1 271.61	.92	1	76 296.0	11 00	253 923	23 913
42	5	2	1 302.63	.93	2	78 157.0	12 00	276 697	28 442
43	5	3	1 333.64	.93	3	80 017.9	13 00	299 390	33 360
44	5	4	1 364.66	.93	4	81 878.8	14 00	321 996	38 664
78 45	31.016	45	1 395.67	1860.93	45	83 739.7	15 00	344 509	44 353
46	6	6	1 426.69	.93	6	85 600.7	16 00	366 920	50 426
47	6	7	1 457.70	.94	7	87 461.6	17 00	389 225	56 881
48	6	8	1 488.72	.94	8	89 322.6	18 00	411 416	63 715
49	6	9	1 519.73	.94	9	91 183.5	19 00	433 488	70 927
78 50	31.016	50	1 550.75	1860.94	50	93 044.4	20 00	455 433	78 515
51	6	1	1 581.76	.94	1	94 905.4	21 00	477 245	86 477
52	6	2	1 612.78	.95	2	96 766.3	22 00	498 918	94 809
53	6	3	1 643.79	.95	3	98 627.2	23 00	520 446	103 511
54	6	4	1 674.81	.95	4	100 488.2	24 00	541 822	112 579
78 55	31.016	55	1 705.82	1860.95	55	102 349.1	25 00	563 041	122 010
56	6	6	1 736.84	.95	6	104 210.1	26 00	584 095	131 802
57	6	7	1 767.85	.96	7	106 071.1	27 00	604 979	141 952
58	6	8	1 798.87	.96	8	107 932.0	28 00	625 686	152 457
59	6	9	1 829.88	.96	9	109 793.0	29 00	646 212	163 314
78 60	31.016	60	1 860.90	1860.96	60	111 653.9	30 00	666 549	174 520

Latitude 79° to 80°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
79 00	5.92	11.84	17.76	23.68	29.60	35.52	41.44	47.36	53.28	355.2	710.4	1065.5	1420.7	1775.9
1	.91	.82	.73	.64	.55	.46	.38	.29	.20	4.6	9.3	3.9	18.6	3.2
2	.90	.80	.71	.61	.51	.41	.31	.22	.12	4.1	8.2	2.3	6.5	70.6
3	.89	.79	.68	.57	.47	.36	.25	.14	3.04	3.6	7.2	60.7	4.3	67.9
4	.88	.77	.65	.54	.42	.31	.19	.07	2.96	3.1	6.1	59.2	2.2	5.3
79 05	5.88	11.75	17.63	23.50	29.38	35.25	41.13	47.00	52.88	352.5	705.0	1057.6	1410.1	1762.6
6	.87	.73	.60	.47	.33	.20	.06	6.93	.80	2.0	4.0	6.0	08.0	59.9
7	.86	.72	.57	.43	.29	.15	1.00	.86	.72	1.5	2.9	4.4	5.8	7.3
8	.85	.70	.55	.39	.24	.09	0.94	.79	.64	0.9	1.8	2.8	3.7	4.6
9	.84	.68	.52	.36	.20	5.04	.88	.72	.56	50.4	700.8	51.2	401.6	52.0
79 10	5.83	11.66	17.49	23.32	29.16	34.99	40.82	46.65	52.48	349.9	699.7	1049.6	1399.4	1749.3
11	.82	.64	.47	.29	.11	.93	.76	.58	.40	9.3	8.7	8.0	7.3	6.7
12	.81	.63	.44	.25	.07	.88	.69	.51	.32	8.8	7.6	6.4	5.2	4.0
13	.80	.61	.41	.22	9.02	.83	.63	.43	.24	8.3	6.5	4.8	3.1	41.3
14	.80	.59	.39	.18	8.98	.77	.57	.36	.16	7.7	5.5	3.2	90.9	38.7
79 15	5.79	11.57	17.36	23.15	28.93	34.72	40.51	46.29	52.08	347.2	694.4	1041.6	1388.8	1736.0
16	.78	.56	.33	.11	.89	.67	.45	.22	2.00	6.7	3.3	40.0	6.7	3.4
17	.77	.54	.31	.08	.85	.61	.38	.15	1.92	6.1	2.3	38.4	4.6	30.7
18	.76	.52	.28	.04	.80	.56	.32	.08	.84	5.6	1.2	6.8	2.4	28.0
19	.75	.50	.25	3.01	.76	.51	.26	6.01	.76	5.1	90.2	5.2	80.3	5.4
79 20	5.74	11.48	17.23	22.97	28.71	34.45	40.20	45.94	51.68	344.5	689.1	1033.6	1378.2	1722.7
21	.73	.47	.20	.93	.67	.40	.14	.87	.60	4.0	8.0	2.0	6.0	20.1
22	.72	.45	.17	.90	.62	.35	.07	.80	.52	3.5	7.0	30.4	3.9	17.4
23	.72	.43	.15	.86	.58	.29	40.01	.73	.44	2.9	5.9	28.8	71.8	4.7
24	.71	.41	.12	.83	.53	.24	39.95	.66	.36	2.4	4.8	7.2	69.7	12.1
79 25	5.70	11.40	17.09	22.79	28.49	34.19	39.89	45.58	51.28	341.9	683.8	1025.6	1367.5	1709.4
26	.69	.38	.07	.76	.45	.14	.83	.51	.20	1.4	2.7	4.1	5.4	6.8
27	.68	.36	.04	.72	.40	.08	.76	.44	.12	0.8	1.6	2.5	3.3	4.1
28	.67	.34	7.01	.69	.36	4.03	.70	.37	1.04	40.3	80.6	20.9	61.1	701.4
29	.66	.33	6.99	.65	.31	3.98	.64	.30	0.96	39.8	79.5	19.3	59.0	698.8
79 30	5.65	11.31	16.96	22.61	28.27	33.92	39.58	45.23	50.88	339.2	678.4	1017.7	1356.9	1696.1
31	.64	.29	.93	.58	.22	.87	.51	.16	.80	8.7	7.4	6.1	4.8	3.4
32	.64	.27	.91	.54	.18	.82	.45	.09	.72	8.2	6.3	4.5	2.6	90.8
33	.63	.25	.88	.51	.14	.76	.39	5.02	.64	7.6	5.2	2.9	50.5	88.1
34	.62	.24	.85	.47	.09	.71	.33	4.94	.56	7.1	4.2	11.3	48.4	5.4
79 35	5.61	11.22	16.83	22.44	28.05	33.66	39.27	44.87	50.48	336.6	673.1	1009.7	1346.2	1682.8
36	.60	.20	.80	.40	8.00	.60	.20	.80	.40	6.0	2.1	8.1	4.1	80.1
37	.59	.18	.78	.37	7.96	.55	.14	.73	.33	5.5	71.0	6.5	42.0	77.5
38	.58	.17	.75	.33	.91	.50	.08	.66	.24	5.0	69.9	4.9	39.9	4.8
39	.57	.15	.72	.30	.87	.44	9.02	.59	.17	4.4	8.9	3.3	7.7	72.2
79 40	5.57	11.13	16.70	22.26	27.83	33.39	38.96	44.52	50.09	333.9	667.8	1001.7	1335.6	1669.5
41	.56	.11	.67	.22	.78	.34	.89	.45	50.00	3.4	6.7	1000.1	3.5	6.8
42	.55	.09	.64	.19	.74	.28	.83	.38	49.93	2.8	5.7	998.5	31.3	4.2
43	.54	.08	.62	.15	.69	.23	.77	.31	.85	2.3	4.6	6.9	29.2	61.5
44	.53	.06	.59	.12	.65	.18	.71	.23	.76	1.8	3.5	5.3	7.1	58.8
79 45	5.52	11.04	16.56	22.08	27.60	33.12	38.64	44.16	49.69	331.2	662.5	993.7	1324.9	1656.2
46	.51	.02	.54	.04	.56	.07	.58	.09	.61	0.7	1.4	2.1	2.8	3.5
47	.50	1.00	.51	2.01	.51	3.02	.52	4.02	.52	30.2	60.3	90.5	20.7	50.8
48	.49	0.99	.48	1.98	.47	2.96	.46	3.95	.45	29.6	59.3	88.9	18.5	48.2
49	.49	.97	.46	.94	.43	.91	.39	.88	.37	9.1	8.2	7.3	6.4	5.5
79 50	5.48	10.95	16.43	21.91	27.38	32.86	38.33	43.81	49.29	328.6	657.2	985.7	1314.3	1642.9
51	.47	.93	.40	.87	.34	.80	.27	.74	.21	8.0	6.1	4.1	2.2	40.2
52	.46	.92	.38	.83	.29	.75	.21	.67	.13	7.5	5.0	2.5	10.0	37.5
53	.45	.90	.35	.80	.25	.70	.14	.60	9.05	7.0	3.9	80.9	07.9	4.9
54	.44	.88	.32	.76	.20	.64	.08	.53	8.97	6.4	2.9	79.3	5.8	32.2
79 55	5.43	10.86	16.30	21.73	27.16	32.59	38.02	43.45	48.89	325.9	651.8	977.4	1303.6	1629.5
56	.42	.85	.27	.69	.12	.54	7.96	.38	.81	5.4	50.7	6.1	301.5	6.9
57	.41	.83	.24	.66	.07	.48	.90	.31	.73	4.8	49.7	4.5	299.4	4.2
58	.41	.81	.21	.62	7.03	.43	.83	.24	.65	4.3	8.6	2.9	7.2	21.5
59	.40	.79	.19	.58	6.98	.38	.77	.17	.56	3.8	7.5	71.3	5.1	18.8
79 60	5.39	10.77	16.16	21.55	26.94	32.32	37.71	43.10	48.49	323.2	646.5	969.7	1293.0	1616.2

Lat.		Latitude 79° to 80°—Meridional arcs.						Latitude 79°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
79	00	31.016			1860.96						
	1	6	1	31.02	.97	1	1 861.0	0	1	355.2	0.1
	2	6	2	62.03	.97	2	3 721.9		2	710.3	0.2
	3	6	3	93.05	.97	3	5 582.9		3	1 065.5	0.5
	4	6	4	124.07	.97	4	7 443.9		4	1 420.7	0.8
79	05	31.016	5	155.09	1860.97	5	9 304.8	0	5	1 775.9	1.3
	6	6	6	186.10	.98	6	11 165.8		6	2 131.1	1.8
	7	6	7	217.12	.98	7	13 026.8		7	2 486.2	2.5
	8	6	8	248.14	.98	8	14 887.8		8	2 841.4	3.2
	9	6	9	279.15	.98	9	16 748.8		9	3 196.6	4.1
79	10	31.016	10	310.17	1860.98	10	18 609.7	0	10	3 551.8	5.1
	11	6	1	341.19	.99	1	20 470.7		15	5 327.6	11.4
	12	6	2	372.20	.99	2	22 331.7		20	7 103.5	20.3
	13	6	3	403.22	.99	3	24 192.7		25	8 879.3	31.7
	14	7	4	434.24	.99	4	26 053.7		30	10 655.2	45.6
79	15	31.017	15	465.26	1860.99	15	27 914.7	0	35	12 431.0	62.1
	16	7	6	496.27	1.00	6	29 775.7		40	14 206.8	81.1
	17	7	7	527.29	.00	7	31 636.7		45	15 982.5	102.7
	18	7	8	558.31	.00	8	33 497.7		50	17 758.2	126.8
	19	7	9	589.32	.00	9	35 358.7		55	19 533.9	153.4
79	20	31.017	20	620.34	1861.00	20	37 219.7	1	00	21 309.6	182.5
	21	7	1	651.36	.01	1	39 080.7		05	23 085.2	214.2
	22	7	2	682.38	.01	2	40 941.7		10	24 860.7	248.5
	23	7	3	713.39	.01	3	42 802.7		15	26 636.2	285.2
	24	7	4	744.41	.01	4	44 663.7		20	28 411.7	324.5
79	25	31.017	25	775.43	1861.01	25	46 524.7	1	25	30 187.1	366.4
	26	7	6	806.44	.02	6	48 385.8		30	31 962.4	410.7
	27	7	7	837.46	.02	7	50 246.8		35	33 737.6	457.6
	28	7	8	868.48	.02	8	52 107.8		40	35 512.8	507.0
	29	7	9	899.49	.02	9	53 968.8		45	37 288.0	559.0
79	30	31.017	30	930.51	1861.02	30	55 829.8	1	50	39 063.0	613.5
	31	7	1	961.53	.03	1	57 690.9		55	40 838.0	670.6
	32	7	2	992.55	.03	2	59 551.9	2	00	42 613	730
	33	7	3	1 023.56	.03	3	61 412.9	3	00	63 904	1 643
	34	7	4	1 054.58	.03	4	63 274.0	4	00	85 176	2 920
79	35	31.017	35	1 085.60	1861.03	35	65 135.0	5	00	106 423	4 561
	36	7	6	1 116.61	.04	6	66 996.0	6	00	127 639	6 566
	37	7	7	1 147.63	.04	7	68 857.1	7	00	148 817	8 934
	38	7	8	1 178.65	.04	8	70 718.1	8	00	169 952	11 665
	39	7	9	1 209.67	.04	9	72 579.2	9	00	191 036	14 758
79	40	31.017	40	1 240.68	1861.04	40	74 440.2	10	00	212 065	18 211
	41	7	1	1 271.70	.05	1	76 301.2	11	00	233 031	22 024
	42	7	2	1 302.72	.05	2	78 162.3	12	00	253 929	26 195
	43	7	3	1 333.73	.05	3	80 023.3	13	00	274 753	30 724
	44	8	4	1 364.75	.05	4	81 884.4	14	00	295 496	35 609
79	45	31.018	45	1 395.77	1861.05	45	83 745.4	15	00	316 152	40 849
	46	8	6	1 426.79	.06	6	85 606.5	16	00	336 715	46 442
	47	8	7	1 457.80	.06	7	87 467.6	17	00	357 180	52 386
	48	8	8	1 488.82	.06	8	89 328.6	18	00	377 540	58 680
	49	8	9	1 519.84	.06	9	91 189.7	19	00	397 788	65 322
79	50	31.018	50	1 550.85	1861.06	50	93 050.7	20	00	417 920	72 310
	51	8	1	1 581.87	.06	1	94 911.8	21	00	437 930	79 641
	52	8	2	1 612.89	.07	2	96 772.9	22	00	457 811	87 315
	53	8	3	1 643.90	.07	3	98 633.9	23	00	477 557	95 328
	54	8	4	1 674.92	.07	4	100 495.0	24	00	497 164	103 678
79	55	31.018	55	1 705.94	1861.07	55	102 356.1	25	00	516 624	112 362
	56	8	6	1 736.96	.07	6	104 217.1	26	00	535 933	121 379
	57	8	7	1 767.97	.08	7	106 078.2	27	00	555 084	130 725
	58	8	8	1 798.99	.08	8	107 939.3	28	00	574 073	140 398
	59	8	9	1 830.01	.08	9	109 800.4	29	00	592 893	150 395
79	60	31.018	60	1 861.02	1861.08	60	111 661.4	30	00	611 539	160 713

Latitude 80° to 81°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
80 00	5.39	10.77	16.16	21.55	26.94	32.32	37.71	43.10	48.49	323.2	646.5	969.7	1293.0	1616.2
1	.38	.76	.13	.51	.89	.27	.65	3.03	.41	2.7	5.4	8.1	90.8	3.5
2	.37	.74	.11	.48	.85	.22	.59	2.96	.33	2.2	4.3	6.5	88.7	10.9
3	.36	.72	.08	.44	.80	.16	.52	.89	.25	1.6	3.3	4.9	6.6	08.2
4	.35	.70	.06	.41	.76	.11	.46	.81	.17	1.1	2.2	3.3	4.4	5.5
80 05	5.34	10.69	16.03	21.37	26.72	32.06	37.40	42.74	48.09	320.6	641.1	961.7	1282.3	1602.9
6	.33	.67	6.00	.34	.67	2.00	.34	.67	8.01	20.0	40.1	60.1	80.2	600.2
7	.33	.65	5.98	.30	.63	1.95	.28	.60	7.93	19.5	39.0	58.5	78.0	597.5
8	.32	.63	.95	.27	.59	.90	.21	.53	.85	9.0	7.9	6.9	5.9	4.9
9	.31	.61	.92	.23	.54	.84	.15	.46	.77	8.4	6.9	5.3	3.8	92.2
80 10	5.30	10.60	15.90	21.19	26.49	31.79	37.09	42.39	47.69	317.9	635.8	953.7	1271.6	1589.5
11	.29	.58	.87	.16	.45	.74	7.03	.32	.61	7.4	4.7	2.1	69.5	6.9
12	.28	.56	.84	.12	.40	.68	6.97	.25	.53	6.8	3.7	50.5	7.4	4.2
13	.27	.54	.82	.09	.36	.63	.90	.17	.45	6.3	2.6	48.9	5.2	81.5
14	.26	.53	.79	.05	.31	.58	.84	.10	.37	5.8	1.6	7.3	3.1	78.9
80 15	5.25	10.51	15.76	21.02	26.27	31.52	36.78	42.03	47.29	315.2	630.5	945.7	1261.0	1576.2
16	.25	.49	.74	0.98	.23	.47	.72	1.96	.21	4.7	29.4	4.1	58.8	3.5
17	.24	.47	.71	.95	.18	.42	.65	.89	.13	4.2	8.3	2.5	6.7	70.9
18	.23	.45	.68	.91	.14	.36	.59	.82	7.05	3.6	7.3	40.9	4.6	68.2
19	.22	.44	.66	.87	.09	.31	.53	.75	6.97	3.1	6.2	39.3	2.4	5.5
80 20	5.21	10.42	15.63	20.84	26.05	31.26	36.47	41.68	46.89	312.6	625.1	937.7	1250.3	1562.9
21	.20	.40	.60	.80	6.00	.20	.40	.61	.81	2.0	4.1	6.1	48.2	60.2
22	.19	.38	.58	.77	5.96	.15	.34	.54	.73	1.5	3.0	4.5	6.0	57.5
23	.18	.37	.55	.73	.92	.10	.28	.46	.65	1.0	1.9	2.9	3.9	4.9
24	.17	.35	.52	.70	.87	1.04	.22	.39	.57	10.4	20.9	31.3	41.7	52.2
80 25	5.17	10.33	15.49	20.66	25.83	30.99	36.15	41.32	46.49	309.9	619.8	929.7	1239.6	1549.5
26	.16	.31	.47	.62	.78	.94	.09	.25	.40	9.4	8.7	8.1	7.5	6.8
27	.15	.29	.44	.59	.74	.88	6.03	.18	.33	8.8	7.7	6.5	5.3	4.2
28	.14	.28	.41	.55	.69	.83	5.97	.11	.25	8.3	6.6	4.9	3.2	41.5
29	.13	.26	.39	.52	.65	.78	.90	1.03	.16	7.8	5.5	3.3	31.1	38.8
80 30	5.12	10.24	15.36	20.48	25.60	30.72	35.85	40.97	46.09	307.2	614.5	921.7	1228.9	1536.2
31	.11	.22	.33	.45	.56	.67	.78	.89	6.01	6.7	3.4	20.1	6.8	3.5
32	.10	.21	.31	.41	.51	.62	.72	.82	5.92	6.2	2.3	18.5	4.7	30.8
33	.09	.19	.28	.38	.47	.56	.66	.75	.85	5.6	1.3	6.9	2.5	28.2
34	.08	.17	.25	.34	.42	.51	.59	.68	.77	5.1	10.2	5.3	20.4	5.5
80 35	5.08	10.15	15.23	20.30	25.38	30.46	35.53	40.61	45.68	304.6	609.1	913.7	1218.3	1522.8
36	.07	.13	.20	.27	.34	.40	.47	.54	.60	4.0	8.1	2.1	6.1	20.1
37	.06	.12	.17	.23	.29	.35	.41	.47	.52	3.5	7.0	10.5	4.0	17.5
38	.05	.10	.15	.20	.25	.30	.35	.39	.44	3.0	5.9	08.9	11.8	4.8
39	.04	.08	.12	.16	.20	.24	.28	.32	.36	2.4	4.9	7.3	09.7	12.1
80 40	5.03	10.06	15.09	20.13	25.16	30.19	35.22	40.25	45.28	301.9	603.8	905.7	1207.6	1509.5
41	.02	.05	.07	.09	.11	.14	.16	.18	.20	1.4	2.7	4.1	5.4	6.8
42	.01	.03	.04	.05	.07	.08	.10	.11	.12	0.8	1.6	2.5	3.3	4.1
43	.00	10.01	5.01	20.02	5.02	30.03	5.03	40.04	5.04	300.3	600.6	900.9	201.2	501.4
44	5.00	9.99	4.99	19.98	4.98	29.98	4.97	39.97	4.96	299.8	599.5	899.3	199.0	498.8
80 45	4.99	9.97	14.96	19.95	24.94	29.92	34.91	39.90	44.88	299.2	598.4	897.7	1196.9	1496.1
46	.98	.96	.93	.91	.89	.87	.85	.82	.80	8.7	7.4	6.1	4.7	3.4
47	.97	.94	.91	.88	.85	.82	.79	.75	.72	8.2	6.3	4.5	2.6	90.8
48	.96	.92	.88	.84	.80	.76	.72	.68	.64	7.6	5.2	2.9	90.5	88.1
49	.95	.90	.85	.81	.76	.71	.66	.61	.56	7.1	4.2	91.3	88.3	5.4
80 50	4.94	9.89	14.83	19.77	24.71	29.66	34.60	39.54	44.48	296.6	593.1	889.7	1186.2	1482.8
51	.93	.87	.80	.73	.67	.60	.54	.47	.40	6.0	2.0	8.0	4.1	80.1
52	.92	.85	.77	.70	.62	.55	.47	.40	.32	5.5	91.0	6.4	81.9	77.4
53	.92	.83	.75	.66	.58	.49	.41	.33	.24	4.9	89.9	4.8	79.8	4.7
54	.91	.81	.72	.63	.53	.44	.35	.26	.16	4.4	8.8	3.2	7.6	72.1
80 55	4.90	9.80	14.69	19.59	24.49	29.39	34.29	39.18	44.08	293.9	587.8	881.6	1175.5	1469.4
56	.89	.78	.67	.56	.45	.33	.22	.11	4.00	3.3	6.7	80.0	3.4	6.7
57	.88	.76	.64	.52	.40	.28	.16	9.04	3.92	2.8	5.6	78.4	71.2	4.0
58	.87	.74	.61	.48	.36	.23	.10	8.97	.84	2.3	4.5	6.8	69.1	61.4
59	.86	.72	.59	.45	.31	.17	4.04	.90	.76	1.7	3.5	5.2	6.9	58.7
80 60	4.85	9.71	14.56	19.41	24.27	29.12	33.97	38.83	43.68	291.2	582.4	873.6	1164.8	1456.0

Lat.		Latitude 80° to 81°—Meridional arcs.						Latitude 80°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	°	′	*Meters.*	*Meters.*
80	00	31.018			1861.08						
	1	8	1	31.02	.08	1	1 861.1	0	1	323.2	0.0
	2	8	2	62.04	.09	2	3 722.2		2	646.5	0.2
	3	8	3	93.06	.09	3	5 583.3		3	969.7	0.4
	4	8	4	124.08	.09	4	7 444.3		4	1 292.9	0.7
80	05	31.018	5	155.09	1861.09	5	9 305.4	0	5	1 616.2	1.2
	6	8	6	186.11	.09	6	11 166.5		6	1 939.4	1.7
	7	8	7	217.13	.10	7	13 027.6		7	2 262.7	2.3
	8	8	8	248.15	.10	8	14 888.7		8	2 585.9	3.0
	9	8	9	279.17	.10	9	16 749.8		9	2 909.1	3.7
80	10	31.018	10	310.19	1861.10	10	18 610.9	0	10	3 232.4	4.6
	11	8	1	341.21	.10	1	20 472.0		15	4 848.6	10.4
	12	8	2	372.23	.10	2	22 333.1		20	6 464.8	18.5
	13	8	3	403.25	.11	3	24 194.2		25	8 080.9	28.9
	14	8	4	434.27	.11	4	26 055.3		30	9 697.1	41.7
80	15	31.019	15	465.28	1861.11	15	27 916.4	0	35	11 313.2	56.7
	16	9	6	496.30	.11	6	29 777.5		40	12 929.3	74.1
	17	9	7	527.32	.11	7	31 638.7		45	14 545.4	93.8
	18	9	8	558.34	.12	8	33 499.8		50	16 161.4	115.7
	19	9	9	589.36	.12	9	35 360.9		55	17 777.5	140.1
80	20	31.019	20	620.38	1861.12	20	37 222.0	1	00	19 393.4	166.7
	21	9	1	651.40	.12	1	39 083.1		05	21 009.4	195.6
	22	9	2	682.42	.12	2	40 944.2		10	22 625.3	226.9
	23	9	3	713.44	.12	3	42 805.4		15	24 241.1	260.4
	24	9	4	744.45	.13	4	44 666.5		20	25 856.9	296.3
80	25	31.019	25	775.47	1861.13	25	46 527.6	1	25	27 472.7	334.5
	26	9	6	806.49	.13	6	48 388.7		30	29 088.4	375.0
	27	9	7	837.51	.13	7	50 249.9		35	30 704.0	417.8
	28	9	8	868.53	.13	8	52 111.0		40	32 319.6	462.9
	29	9	9	899.55	.14	9	53 972.1		45	33 935.1	510.3
80	30	31.019	30	930.57	1861.14	30	55 833.3	1	50	35 550.5	560.1
	31	9	1	961.59	.14	1	57 694.4		55	37 165.9	612.2
	32	9	2	992.61	.14	2	59 555.6	2	00	38 781	667
	33	9	3	1 023.63	.14	3	61 416.7	3	00	58 157	1 500
	34	9	4	1 054.64	.14	4	63 277.8	4	00	77 516	2 666
80	35	31.019	35	1 085.66	1861.15	35	65 139.0	5	00	96 853	4 164
	36	9	6	1 116.68	.15	6	67 000.1	6	00	116 160	5 995
	37	9	7	1 147.70	.15	7	68 861.3	7	00	135 433	8 197
	38	9	8	1 178.72	.15	8	70 722.4	8	00	154 667	10 651
	39	9	9	1 209.74	.15	9	72 583.6	9	00	173 854	13 474
80	40	31.019	40	1 240.76	1861.16	40	74 444.7	10	00	192 990	16 627
	41	9	1	1 271.78	.16	1	76 305.9	11	00	212 070	20 108
	42	9	2	1 302.80	.16	2	78 167.1	12	00	231 086	23 916
	43	9	3	1 333.82	.16	3	80 028.2	13	00	250 034	28 051
	44	9	4	1 364.83	.16	4	81 889.4	14	00	268 909	32 511
80	45	31.019	45	1 395.85	1861.16	45	83 750.5	15	00	287 704	37 295
	46	9	6	1 426.87	.17	6	85 611.7	16	00	306 414	42 401
	47	9	7	1 457.89	.17	7	87 472.9	17	00	325 033	47 828
	48	19	8	1 488.91	.17	8	89 334.0	18	00	343 557	53 574
	49	20	9	1 519.93	.17	9	91 195.2	19	00	361 978	59 637
80	50	31.020	50	1 550.95	1861.17	50	93 056.4	20	00	380 293	66 017
	51	0	1	1 581.97	.17	1	94 917.6	21	00	398 496	72 710
	52	0	2	1 612.99	.18	2	96 778.7	22	00	416 581	79 715
	53	0	3	1 644.00	.18	3	98 639.9	23	00	434 543	87 030
	54	0	4	1 675.02	.18	4	100 501.1	24	00	452 376	94 652
80	55	31.020	55	1 706.04	1861.18	55	102 362.3	25	00	470 076	102 580
	56	0	6	1 737.06	.18	6	104 223.5	26	00	487 637	110 811
	57	0	7	1 768.08	.19	7	106 084.6	27	00	505 054	119 342
	58	0	8	1 799.10	.19	8	107 945.8	28	00	522 322	128 172
	59	0	9	1 830.12	.19	9	109 807.0	29	00	539 435	137 297
80	60	31.020	60	1 861.14	1861.19	60	111 668.2	30	00	556 389	146 715

Latitude 81° to 82°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
81 00	4.85	9.71	14.56	19.41	24.27	29.12	33.97	38.83	43.68	291.2	582.4	873.6	1164.8	1456.0
1	.84	.69	.53	.38	.22	.07	.91	.75	.60	0.7	1.3	2.0	2.7	3.3
2	.84	.67	.51	.34	.18	9.01	.85	.69	.52	90.1	80.3	70.4	60.5	50.7
3	.83	.65	.48	.31	.13	8.96	.79	.61	.44	89.6	79.2	68.8	58.4	48.0
4	.82	.64	.45	.27	.09	.91	.72	.54	.36	9.1	8.1	7.2	6.3	5.3
81 05	4.81	9.62	14.43	19.23	24.04	28.85	33.66	38.47	43.28	288.5	577.1	865.6	1154.1	1442.6
6	.80	.60	.40	.20	4.00	.80	.60	.40	.20	8.0	6.0	4.0	52.0	40.0
7	.79	.58	.37	.16	3.96	.75	.54	.33	.12	7.5	4.9	2.4	49.8	37.3
8	.78	.56	.35	.13	.91	.69	.47	.26	3.04	6.9	3.8	60.8	7.7	4.6
9	.77	.55	.32	.09	.87	.64	.41	.18	2.96	6.4	2.8	59.2	5.6	31.9
81 10	4.76	9.53	14.29	19.06	23.82	28.59	33.35	38.11	42.88	285.9	571.7	957.6	1143.4	1429.3
11	.76	.51	.27	9.02	.78	.53	.29	8.04	.80	5.3	70.6	6.0	41.3	6.6
12	.75	.49	.24	8.99	.73	.48	.22	7.97	.72	4.8	69.6	4.4	39.1	3.9
13	.74	.47	.21	.95	.69	.42	.16	.90	.64	4.2	8.5	2.7	7.0	21.2
14	.73	.46	.19	.91	.64	.37	.10	.83	.56	3.7	7.4	51.1	4.9	18.6
81 15	4.72	9.44	14.16	18.88	23.60	28.32	33.04	37.76	42.48	283.2	566.4	849.5	1132.7	1415.9
16	.71	.42	.13	.84	.55	.26	2.98	.69	.40	2.6	5.3	7.9	30.6	3.2
17	.70	.40	.11	.81	.51	.21	.91	.61	.32	2.1	4.2	6.3	28.4	10.5
18	.69	.39	.08	.77	.47	.16	.85	.54	.23	1.6	3.1	4.7	6.3	07.9
19	.68	.37	.05	.74	.42	.10	.79	.47	.16	1.0	2.1	3.1	4.2	5.2
81 20	4.68	9.35	14.03	18.70	23.38	28.05	32.73	37.40	42.08	280.5	561.0	841.5	1122.0	1402.5
21	.67	.33	4.00	.66	.33	8.00	.66	.33	1.99	80.0	59.9	39.9	19.9	399.8
22	.66	.31	3.97	.63	.29	7.94	.60	.26	.92	79.4	8.9	8.3	7.7	7.2
23	.65	.30	.95	.59	.24	.89	.54	.19	.84	8.9	7.8	6.7	5.6	4.5
24	.64	.28	.92	.56	.20	.84	.48	.11	.75	8.4	6.7	5.1	3.5	91.8
81 25	4.63	9.26	13.89	18.52	23.15	27.78	32.41	37.04	41.67	277.8	555.7	833.5	1111.3	1389.1
26	.62	.24	.87	.48	.11	.73	.35	6.97	.59	7.3	4.6	1.9	09.2	6.5
27	.61	.22	.84	.45	.06	.68	.29	.90	.51	6.8	3.5	30.3	7.0	3.8
28	.60	.21	.81	.41	3.02	.62	.23	.83	.43	6.2	2.4	28.7	4.9	81.1
29	.59	.19	.78	.38	2.97	.57	.16	.76	.35	5.7	1.4	7.1	2.7	78.4
81 30	4.59	9.17	13.76	18.34	22.93	27.51	32.10	36.69	41.27	275.1	550.3	825.4	1100.6	1375.7
31	.58	.15	.73	.31	.89	.46	2.04	.62	.19	4.6	49.2	3.8	098.5	3.1
32	.57	.14	.70	.27	.84	.41	1.98	.54	.11	4.1	8.2	2.2	6.3	70.4
33	.56	.12	.68	.24	.80	.35	.91	.47	1.03	3.5	7.1	20.6	4.2	67.7
34	.55	.10	.65	.20	.75	.30	.85	.40	0.95	3.0	6.0	19.0	92.0	5.0
81 35	4.54	9.08	13.62	18.17	22.71	27.25	31.79	36.33	40.87	272.5	544.9	817.4	1089.9	1362.4
36	.53	.06	.60	.13	.66	.19	.73	.26	.79	1.9	3.9	5.8	7.7	59.7
37	.52	.05	.57	.09	.62	.14	.66	.19	.71	1.4	2.8	4.2	5.6	7.0
38	.51	.03	.54	.06	.57	.09	.60	.11	.63	0.9	1.7	2.6	3.5	4.3
39	.51	9.01	.52	8.02	.53	7.03	.54	6.05	.55	70.3	40.7	11.0	81.3	51.7
81 40	4.50	8.99	13.49	17.99	22.48	26.98	31.48	35.97	40.47	269.8	539.6	809.4	1079.2	1349.0
41	.49	.98	.46	.95	.44	.93	.41	.90	.39	9.3	8.5	7.8	7.0	6.3
42	.48	.96	.44	.91	.39	.87	.35	.83	.31	8.7	7.4	6.2	4.9	3.6
43	.47	.94	.41	.88	.35	.82	.29	.76	.23	8.2	6.4	4.6	2.7	40.9
44	.46	.92	.38	.84	.30	.77	.23	.69	.15	7.7	5.3	3.0	70.6	38.3
81 45	4.45	8.90	13.36	17.81	22.26	26.71	31.16	35.62	40.07	267.1	534.2	801.3	1068.5	1335.6
46	.44	.89	.33	.77	.22	.66	.10	.54	39.99	6.6	3.2	799.7	6.3	2.9
47	.43	.87	.30	.74	.17	.60	1.04	.47	.91	6.0	2.1	8.1	4.2	30.2
48	.43	.85	.27	.70	.13	.55	0.98	.40	.83	5.5	31.0	6.5	62.0	27.5
49	.42	.83	.25	.67	.08	.50	.91	.33	.75	5.0	30.0	4.9	59.9	4.9
81 50	4.41	8.81	13.22	17.63	22.04	26.44	30.85	35.26	39.67	264.4	528.9	793.3	1057.7	1322.2
51	.40	.80	.19	.59	1.99	.39	.79	.19	.59	3.9	7.8	1.7	5.6	19.5
52	.39	.78	.17	.56	.95	.34	.73	.11	.50	3.4	6.7	90.1	3.5	6.8
53	.38	.76	.14	.52	.90	.28	.66	5.04	.42	2.8	5.7	88.5	51.3	4.1
54	.37	.74	.11	.49	.86	.23	.60	4.97	.35	2.3	4.6	6.9	49.2	11.5
81 55	4.36	8.73	13.09	17.45	21.81	26.18	30.54	34.90	39.26	261.8	523.5	785.3	1047.0	1308.8
56	.35	.71	.06	.41	.77	.12	.48	.83	.18	1.2	2.4	3.7	4.9	6.1
57	.34	.69	.03	.38	.72	.07	.41	.76	.10	0.7	1.4	2.0	2.7	3.4
58	.34	.67	3.01	.34	.68	6.02	.35	.69	9.02	60.2	20.3	80.4	40.6	300.7
59	.33	.65	2.98	.31	.64	5.96	.29	.62	8.94	59.6	19.2	78.8	38.4	298.1
81 60	4.32	8.64	12.95	17.27	21.59	25.91	30.23	34.54	38.86	259.1	518.2	777.2	1036.3	1295.4

Lat.		Latitude 81° to 82°—Meridional arcs.						Latitude 81°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
81	00	31.020	.		1861.19						
	1	0	1	31.02	.19	1	1 861.2	0	1	291.2	0.0
	2	0	2	62.04	.19	2	3 722.4		2	582.4	0.2
	3	0	3	93.06	.20	3	5 583.6		3	873.6	0.4
	4	0	4	124.08	.20	4	7 444.8		4	1 164.8	0.7
81	05	31.020	5	155.10	1861.20	5	9 306.0	0	5	1 456.0	1.0
	6	0	6	186.12	.20	6	11 167.2		6	1 747.2	1.5
	7	0	7	217.14	.20	7	13 028.4		7	2 038.4	2.0
	8	0	8	248.17	.20	8	14 889.6		8	2 329.6	2.7
	9	0	9	279.19	.21	9	16 750.8		9	2 620.8	3.4
81	10	31.020	10	310.21	1861.21	10	18 612.0	0	10	2 912.0	4.2
	11	0	1	341.23	.21	1	20 473.2		15	4 368.0	9.4
	12	0	2	372.25	.21	2	22 334.4		20	5 824.0	16.7
	13	0	3	403.27	.21	3	24 195.6		25	7 280.0	26.1
	14	0	4	434.29	.21	4	26 056.8		30	8 736.0	37.6
81	15	31.020	15	465.31	1861.22	15	27 918.0	0	35	10 191.9	51.2
	16	0	6	496.33	.22	6	29 779.3		40	11 647.9	66.9
	17	0	7	527.35	.22	7	31 640.5		45	13 103.8	84.7
	18	0	8	558.37	.22	8	33 501.7		50	14 559.6	104.6
	19	0	9	589.39	.22	9	35 362.9		55	16 015.5	126.5
81	20	31.020	20	620.41	1861.22	20	37 224.1	1	00	17 471.3	150.6
	21	0	1	651.43	.23	1	39 085.4		05	18 927.1	176.7
	22	0	2	682.45	.23	2	40 946.6		10	20 382.8	205.0
	23	0	3	713.48	.23	3	42 807.8		15	21 838.5	235.3
	24	1	4	744.50	.23	4	44 669.0		20	23 294.2	267.7
81	25	31.021	25	775.52	1861.23	25	46 530.3	1	25	24 749.8	302.2
	26	1	6	806.54	.23	6	48 391.5		30	26 205.3	338.8
	27	1	7	837.56	.24	7	50 252.7		35	27 660.8	377.5
	28	1	8	868.58	.24	8	52 114.0		40	29 116.3	418.3
	29	1	9	899.60	.24	9	53 975.2		45	30 571.7	461.2
81	30	31.021	30	930.62	1861.24	30	55 836.5	1	50	32 027.0	506.1
	31	1	1	961.64	.24	1	57 697.7		55	33 482.2	553.2
	32	1	2	992.66	.24	2	59 558.9	2	00	34 937	602
	33	1	3	1 023.68	.24	3	61 420.2	3	00	52 393	1 355
	34	1	4	1 054.70	.25	4	63 281.4	4	00	69 833	2 409
81	35	31.021	35	1 085.72	1861.25	35	65 142.7	5	00	87 253	3 763
	36	1	6	1 116.74	.25	6	67 003.9	6	00	104 646	5 417
	37	1	7	1 147.76	.25	7	68 865.2	7	00	122 009	7 370
	38	1	8	1 178.79	.25	8	70 726.4	8	00	139 335	9 623
	39	1	9	1 209.81	.25	9	72 587.7	9	00	156 620	12 174
81	40	31.021	40	1 240.83	1861.26	40	74 448.9	10	00	173 858	15 022
	41	1	1	1 271.85	.26	1	76 310.2	11	00	191 044	18 168
	42	1	2	1 302.87	.26	2	78 171.5	12	00	208 174	21 609
	43	1	3	1 333.89	.26	3	80 032.7	13	00	225 242	25 344
	44	1	4	1 364.91	.26	4	81 894.0	14	00	242 243	29 374
81	45	31.021	45	1 395.93	1861.26	45	83 755.2	15	00	259 172	33 696
	46	1	6	1 426.95	.27	6	85 616.5	16	00	276 024	38 309
	47	1	7	1 457.97	.27	7	87 477.8	17	00	292 794	43 212
	48	1	8	1 488.99	.27	8	89 339.0	18	00	309 477	48 403
	49	1	9	1 520.01	.27	9	91 200.3	19	00	326 068	53 881
81	50	31.021	50	1 551.03	1861.27	50	93 061.6	20	00	342 562	59 644
	51	1	1	1 582.05	.27	1	94 922.9	21	00	358 954	65 691
	52	1	2	1 613.07	.27	2	96 784.1	22	00	375 240	72 019
	53	1	3	1 644.10	.28	3	98 645.4	23	00	391 414	78 627
	54	1	4	1 675.12	.28	4	100 506.7	24	00	407 472	85 513
81	55	31.021	55	1 706.14	1861.28	55	102 368.0	25	00	423 408	92 675
	56	1	6	1 737.16	.28	6	104 229.3	26	00	439 219	100 110
	57	1	7	1 768.18	.28	7	106 090.5	27	00	454 900	107 817
	58	1	8	1 799.20	.28	8	107 951.8	28	00	470 445	115 793
	59	1	9	1 830.22	.29	9	109 813.1	29	00	485 850	124 036
81	60	31.021	60	1 861.24	1861.29	60	111 674.4	30	00	501 111	132 543

Latitude 82° to 83°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
82 00	4.32	8.64	12.95	17.27	21.59	25.91	30.23	34.54	38.86	259.1	518.2	777.2	1036.3	1295.4
1	.31	.62	.93	.24	.55	.85	.16	.47	.78	8.5	7.1	5.6	4.2	2.7
2	.30	.60	.90	.20	.50	.80	.10	.40	.70	8.0	6.0	4.0	32.0	90.0
3	.29	.58	.87	.16	.46	.75	30.04	.33	.62	7.5	4.9	2.4	29.9	87.3
4	.28	.56	.85	.13	.41	.69	29.98	.26	.54	6.9	3.9	70.8	7.7	4.6
82 05	4.27	8.55	12.82	17.09	21.37	25.64	29.91	34.18	38.46	256.4	512.8	769.2	1025.6	1282.0
6	.26	.53	.79	.06	.32	.59	.85	.11	.38	5.9	1.7	7.6	3.4	79.3
7	.26	.51	.77	17.02	.28	.53	.79	4.04	.30	5.3	10.6	6.0	21.3	6.6
8	.25	.49	.74	6.99	.23	.48	.72	3.97	.22	4.8	09.6	4.4	19.1	3.9
9	.24	.47	.71	.95	.19	.42	.66	.90	.14	4.2	8.5	2.7	7.0	71.2
82 10	4.23	8.46	12.69	16.91	21.14	25.37	29.60	33.83	38.06	253.7	507.4	761.1	1014.8	1268.6
11	.22	.44	.66	.88	.10	.32	.54	.76	7.98	3.2	6.4	59.5	2.7	5.9
12	.21	.42	.63	.84	.05	.26	.47	.69	.90	2.6	5.3	7.9	10.6	3.2
13	.20	.40	.61	.81	1.01	.21	.41	.61	.82	2.1	4.2	6.3	08.4	60.5
14	.19	.39	.58	.77	0.96	.16	.35	.54	.73	1.6	3.1	4.7	6.3	57.8
82 15	4.18	8.37	12.55	16.74	20.92	25.10	29.29	33.47	37.65	251.0	502.0	753.1	1004.1	1255.1
16	.18	.35	.53	.70	.88	.05	.22	.40	.57	0.5	501.0	51.5	1002.0	52.5
17	.17	.33	.50	.66	.83	5.00	.16	.33	.49	50.0	499.9	49.9	999.8	49.8
18	.16	.31	.47	.63	.79	4.94	.10	.25	.41	49.4	8.8	8.3	7.7	7.1
19	.15	.30	.44	.59	.74	.89	9.04	.18	.33	8.9	7.8	6.6	5.5	4.4
82 20	4.14	8.28	12.42	16.56	20.70	24.83	28.97	33.11	37.25	248.3	496.7	745.0	993.4	1241.7
21	.13	.26	.39	.52	.65	.78	.91	3.04	.17	7.8	5.6	3.4	91.2	39.1
22	.12	.24	.36	.49	.61	.73	.85	2.97	.09	7.3	4.5	1.8	89.1	6.4
23	.11	.22	.34	.45	.56	.67	.78	.90	7.01	6.7	3.5	40.2	6.9	3.7
24	.10	.21	.31	.41	.52	.62	.72	.83	6.93	6.2	2.4	38.6	4.8	31.0
82 25	4.09	8.19	12.28	16.38	20.47	24.57	28.66	32.75	36.85	245.7	491.3	737.0	982.7	1228.3
26	.09	.17	.26	.34	.43	.51	.60	.68	.77	5.1	90.2	5.4	80.5	5.6
27	.08	.15	.23	.31	.38	.46	.53	.61	.69	4.6	89.2	3.8	78.4	2.9
28	.07	.14	.20	.27	.34	.41	.47	.54	.61	4.1	8.1	2.2	6.2	20.3
29	.06	.12	.18	.23	.29	.35	.41	.47	.53	3.5	7.0	30.5	4.1	17.6
82 30	4.05	8.10	12.15	16.20	20.25	24.30	28.35	32.40	36.45	243.0	486.0	728.9	971.9	1214.9
31	.04	.08	.12	.16	.20	.24	.28	.33	.37	2.4	4.9	7.3	69.8	12.2
32	.03	.06	.10	.13	.16	.19	.22	.25	.29	1.9	3.8	5.7	7.6	09.5
33	.02	.05	.07	.09	.12	.14	.16	.18	.21	1.4	2.7	4.1	5.5	6.9
34	.01	.03	.04	.06	.07	.08	.10	.11	.13	0.8	1.7	2.5	3.3	4.2
82 35	4.01	8.01	12.02	16.02	20.03	24.03	28.03	32.04	36.04	240.3	480.6	720.9	961.2	1201.5
36	4.00	7.99	1.99	5.98	19.98	3.98	7.97	1.97	5.96	39.8	79.5	19.3	59.0	198.8
37	3.99	.97	.96	.95	.94	.92	.91	.90	.88	9.2	8.4	7.7	6.9	6.1
38	.98	.96	.93	.91	.89	.87	.85	.82	.80	8.7	7.4	6.1	4.7	3.4
39	.97	.94	.91	.88	.85	.81	.78	.75	.72	8.1	6.3	4.4	2.6	90.7
82 40	3.96	7.92	11.88	15.84	19.80	23.76	27.72	31.68	35.64	237.6	475.2	712.8	950.4	1188.1
41	.95	.90	.85	.81	.76	.71	.66	.61	.56	7.1	4.2	11.2	48.3	5.4
42	.94	.88	.83	.77	.71	.65	.60	.54	.48	6.5	3.1	09.6	6.1	2.7
43	.93	.87	.80	.73	.67	.60	.53	.47	.40	6.0	2.0	8.0	4.0	80.0
44	.92	.85	.77	.70	.62	.55	.47	.39	.32	5.5	70.9	6.4	41.8	77.3
82 45	3.92	7.83	11.75	15.66	19.58	23.49	27.41	31.32	35.24	234.9	469.9	704.8	939.7	1174.6
46	.91	.81	.72	.63	.53	.44	.34	.25	.16	4.4	8.8	3.2	7.6	71.9
47	.90	.80	.69	.59	.49	.39	.28	.18	.08	3.9	7.7	701.6	5.4	69.3
48	.89	.78	.67	.55	.44	.33	.22	.11	5.00	3.3	6.6	699.9	3.3	6.6
49	.88	.76	.64	.52	.40	.28	.16	1.04	4.92	2.8	5.6	8.3	31.1	3.9
82 50	3.87	7.74	11.61	15.48	19.35	23.22	27.09	30.97	34.84	232.2	464.5	696.7	929.0	1161.2
51	.86	.72	.58	.45	.31	.17	7.03	.89	.76	1.7	3.4	5.1	6.8	58.5
52	.85	.71	.56	.41	.26	.12	6.97	.82	.67	1.2	2.3	3.5	4.7	5.8
53	.84	.69	.53	.37	.22	.06	.90	.75	.59	0.6	1.3	1.9	2.5	3.1
54	.83	.67	.50	.34	.17	3.01	.84	.68	.52	30.1	60.2	90.3	20.4	50.5
82 55	3.83	7.65	11.48	15.30	19.13	22.96	26.78	30.61	34.43	229.6	459.1	688.7	918.2	1147.8
56	.82	.63	.45	.27	.09	.90	.72	.54	.35	9.0	8.0	7.0	6.1	5.1
57	.81	.62	.42	.23	.04	.85	.66	.46	.27	8.5	7.0	5.4	3.9	42.4
58	.80	.60	.40	.20	9.00	.79	.59	.39	.19	7.9	5.9	3.8	11.8	39.7
59	.79	.58	.37	.16	8.95	.74	.53	.32	.11	7.4	4.8	2.2	09.6	7.0
82 60	3.78	7.56	11.34	15.12	18.91	22.69	26.47	30.25	34.03	226.9	453.7	680.6	907.5	1134.3

Lat.		Latitude 82° to 83°—Meridional arcs.						Latitude 82°—Co-ordinates of curvature.			
		Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
82	00	31.021			1861.29						
	1	1	1	31.02	.29	1	1 861.3	0	1	259.1	0.0
	2	2	2	62.04	.29	2	3 722.6		2	518.1	0.2
	3	2	3	93.07	.29	3	5 583.9		3	777.2	0.3
	4	2	4	124.09	.29	4	7 445.2		4	1 036.3	0.6
82	05	31.022	5	155.11	1861.29	5	9 306.5	0	5	1 295.4	0.9
	6	2	6	186.13	.30	6	11 167.7		6	1 554.5	1.3
	7	2	7	217.16	.30	7	13 029.0		7	1 813.5	1.8
	8	2	8	248.18	.30	8	14 890.3		8	2 072.6	2.4
	9	2	9	279.20	.30	9	16 751.6		9	2 331.7	3.0
82	10	31.022	10	310.22	1861.30	10	18 612.9	0	10	2 590.8	3.7
	11	2	1	341.24	.30	1	20 474.2		15	3 886.1	8.4
	12	2	2	372.27	.30	2	22 335.6		20	5 181.5	14.9
	13	2	3	403.29	.31	3	24 196.9		25	6 476.8	23.3
	14	2	4	434.31	.31	4	26 058.2		30	7 772.2	33.6
82	15	31.022	15	465.33	1861.31	15	27 919.5	0	35	9 067.5	45.7
	16	2	6	496.36	.31	6	29 780.8		40	10 362.8	59.7
	17	2	7	527.38	.31	7	31 642.1		45	11 658.1	75.6
	18	2	8	558.40	.31	8	33 503.4		50	12 953.3	93.3
	19	2	9	589.42	.32	9	35 364.7		55	14 248.5	112.9
82	20	31.022	20	620.44	1861.32	20	37 226.0	1	00	15 543.7	134.3
	21	2	1	651.47	.32	1	39 087.4		05	16 838.9	157.6
	22	2	2	682.49	.32	2	40 948.7		10	18 134.0	182.8
	23	2	3	713.51	.32	3	42 810.0		15	19 429.1	209.9
	24	2	4	744.53	.32	4	44 671.3		20	20 724.2	238.8
82	25	31.022	25	775.55	1861.32	25	46 532.6	1	25	22 019.2	269.6
	26	2	6	806.58	.33	6	48 394.0		30	23 314.2	302.2
	27	2	7	837.60	.33	7	50 255.3		35	24 609.1	336.7
	28	2	8	868.62	.33	8	52 116.6		40	25 904.0	373.1
	29	2	9	899.64	.33	9	53 978.0		45	27 198.8	411.4
82	30	31.022	30	930.67	1861.33	30	55 839.3	1	50	28 493.5	451.5
	31	2	1	961.69	.33	1	57 700.6		55	29 788.2	493.5
	32	2	2	992.71	.33	2	59 562.0	2	00	31 083	537
	33	2	3	1 023.73	.34	3	61 423.3	3	00	46 613	1 209
	34	2	4	1 054.75	.34	4	63 284.6	4	00	62 129	2 148
82	35	31.022	35	1 085.78	1861.34	35	65 146.0	5	00	77 626	3 356
	36	2	6	1 116.80	.34	6	67 007.3	6	00	93 100	4 832
	37	2	7	1 147.82	.34	7	68 868.6	7	00	108 546	6 574
	38	2	8	1 178.84	.34	8	70 730.0	8	00	123 960	8 583
	39	2	9	1 209.87	.34	9	72 591.3	9	00	139 337	10 859
82	40	31.022	40	1 240.89	1861.35	40	74 452.7	10	00	154 672	13 400
	41	2	1	1 271.91	.35	1	76 314.0	11	00	169 962	16 205
	42	2	2	1 302.93	.35	2	78 175.4	12	00	185 200	19 274
	43	2	3	1 333.95	.35	3	80 036.7	13	00	200 383	22 607
	44	3	4	1 364.98	.35	4	81 898.1	14	00	215 506	26 201
82	45	31.023	45	1 396.00	1861.35	45	83 759.4	15	00	230 565	30 056
	46	3	6	1 427.02	.35	6	85 620.8	16	00	245 555	34 170
	47	3	7	1 458.04	.36	7	87 482.1	17	00	260 471	38 543
	48	3	8	1 489.07	.36	8	89 343.5	18	00	275 310	43 173
	49	3	9	1 520.09	.36	9	91 204.9	19	00	290 066	48 059
82	50	31.023	50	1 551.11	1861.36	50	93 066.2	20	00	304 736	53 200
	51	3	1	1 582.13	.36	1	94 927.6	21	00	319 315	58 593
	52	3	2	1 613.15	.36	2	96 788.9	22	00	333 798	64 237
	53	3	3	1 644.18	.36	3	98 650.3	23	00	348 182	70 130
	54	3	4	1 675.20	.36	4	100 511.7	24	00	362 462	76 272
82	55	31.023	55	1 706.22	1861.37	55	102 373.0	25	00	376 633	82 659
	56	3	6	1 737.24	.37	6	104 234.4	26	00	390 692	89 290
	57	3	7	1 768.26	.37	7	106 095.8	27	00	404 634	96 163
	58	3	8	1 799.29	.37	8	107 957.1	28	00	418 456	103 276
	59	3	9	1 830.31	.37	9	109 818.5	29	00	432 152	110 627
82	60	31.023	60	1 861.33	1861.37	60	111 679.9	30	00	445 719	118 214

Latitude 83° to 84°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
83 00	3.78	7.56	11.34	15.12	18.91	22.69	26.47	30.25	34.03	226.9	453.7	680.6	907.5	1134.3
1	.77	.55	.32	.09	.86	.63	.41	.18	3.95	6.3	2.7	79.0	5.3	1.7
2	.76	.53	.29	.05	.82	.58	.34	.11	.87	5.8	1.6	7.4	3.2	29.0
3	.75	.51	.26	5.02	.77	.53	.28	30.03	.79	5.3	50.6	5.8	901.0	6.3
4	.75	.49	.24	4.98	.73	.47	.22	29.96	.71	4.7	49.4	4.1	898.9	3.6
83 05	3.74	7.47	11.20	14.95	18.68	22.42	26.16	29.89	33.63	224.2	448.4	672.5	896.7	1120.9
6	.73	.45	.18	.91	.64	.36	.09	.82	.55	3.6	7.3	70.9	4.6	18.2
7	.72	.44	.15	.87	.59	.31	6.03	.75	.46	3.1	6.2	69.3	2.4	5.5
8	.71	.42	.13	.84	.55	.26	5.97	.67	.38	2.6	5.1	7.7	90.3	2.8
9	.70	.40	.10	.80	.50	.20	.90	.60	.30	2.0	4.1	6.1	88.1	10.1
83 10	3.69	7.38	11.07	14.77	18.46	22.15	25.84	29.53	33.22	221.5	443.0	664.5	886.0	1107.5
11	.68	.36	.05	.73	.41	.10	.78	.46	.14	1.0	1.9	2.9	3.8	4.8
12	.67	.35	1.02	.69	.37	2.04	.72	.39	3.06	20.4	40.8	61.2	81.7	102.1
13	.66	.33	0.99	.66	.32	1.99	.65	.32	2.98	19.9	39.8	59.6	79.5	099.4
14	.66	.31	.97	.62	.28	.93	.59	.25	.90	9.3	8.7	8.0	7.4	6.7
83 15	3.65	7.29	10.94	14.59	18.23	21.88	25.53	29.17	32.82	218.8	437.6	656.4	875.2	1094.0
16	.64	.28	.91	.55	.19	.83	.46	.10	.74	8.3	6.5	4.8	3.1	91.3
17	.63	.26	.89	.51	.14	.77	.40	9.03	.66	7.7	5.4	3.2	70.9	88.6
18	.62	.24	.86	.48	.10	.72	.34	8.96	.58	7.2	4.4	1.6	68.8	6.0
19	.61	.22	.83	.44	.06	.67	.27	.89	.50	6.7	3.3	50.0	6.6	3.3
83 20	3.60	7.20	10.81	14.41	18.01	21.61	25.21	28.82	32.42	216.1	432.2	648.3	864.5	1080.6
21	.59	.19	.78	.37	7.97	.56	.15	.74	.34	5.6	1.2	6.7	2.3	77.9
22	.58	.17	.75	.34	.92	.50	.09	.67	.26	5.0	30.1	5.1	60.2	5.2
23	.57	.15	.73	.30	.88	.45	5.02	.60	.18	4.5	29.0	3.5	58.0	72.5
24	.57	.13	.70	.26	.83	.40	4.96	.53	.09	4.0	7.9	1.9	5.9	69.8
83 25	3.56	7.11	10.67	14.23	17.79	21.34	24.90	28.46	32.01	213.4	426.9	640.3	853.7	1067.1
26	.55	.10	.64	.19	.74	.29	.84	.38	1.93	2.9	5.8	38.7	51.6	4.4
27	.54	.08	.62	.16	.70	.24	.78	.31	.85	2.4	4.7	7.1	49.4	61.8
28	.53	.06	.59	.12	.65	.18	.71	.24	.77	1.8	3.6	5.4	7.3	59.1
29	.52	.04	.56	.09	.61	.13	.65	.17	.69	1.3	2.6	3.8	5.1	6.4
83 30	3.51	7.02	10.54	14.05	17.56	21.07	24.59	28.10	31.61	210.7	421.5	632.2	843.0	1053.7
31	.50	7.01	.51	4.01	.52	1.02	.52	8.03	.53	10.2	20.4	30.6	40.8	51.0
32	.49	6.99	.48	3.98	.47	0.97	.46	7.95	.45	09.7	19.3	29.0	38.6	48.3
33	.49	.97	.46	.94	.43	.91	.40	.88	.37	9.1	8.2	7.4	6.5	5.6
34	.48	.95	.43	.91	.38	.86	.33	.81	.29	8.6	7.2	5.8	4.3	2.9
83 35	3.47	6.93	10.40	13.87	17.34	20.80	24.27	27.74	31.21	208.0	416.1	624.1	832.2	1040.2
36	.46	.92	.38	.83	.29	.75	.21	.67	.12	7.5	5.0	2.5	30.0	37.5
37	.45	.90	.35	.80	.25	.70	.15	.60	1.05	7.0	3.9	20.9	27.9	4.9
38	.44	.88	.32	.76	.20	.64	.08	.52	0.97	6.4	2.9	19.3	5.7	32.2
39	.43	.86	.30	.73	.16	.59	4.02	.45	.88	5.9	1.8	7.7	3.6	29.5
83 40	3.42	6.85	10.27	13.69	17.11	20.54	23.96	27.38	30.80	205.4	410.7	616.1	821.4	1026.8
41	.41	.83	.24	.65	.07	.48	.90	.31	.72	4.8	09.6	4.5	19.3	4.1
42	.40	.81	.21	.62	7.02	.43	.83	.24	.64	4.3	8.6	2.8	7.1	21.4
43	.40	.79	.19	.58	6.98	.37	.77	.17	.56	3.7	7.5	11.2	5.0	18.7
44	.39	.77	.16	.55	.93	.32	.71	.09	.48	3.2	6.4	09.6	2.8	6.0
83 45	3.38	6.76	10.13	13.51	16.89	20.27	23.64	27.02	30.40	202.7	405.3	608.0	810.7	1013.3
46	.37	.74	.11	.47	.84	.21	.58	6.95	.32	2.1	4.3	6.4	08.5	10.6
47	.36	.72	.08	.44	.80	.16	.52	.88	.24	1.6	3.2	4.8	6.4	07.9
48	.35	.70	.05	.40	.75	.11	.46	.81	.16	1.1	2.1	3.2	4.2	5.3
49	.34	.68	.03	.37	.71	.05	.39	.74	.08	0.5	1.0	601.5	802.1	1002.6
83 50	3.33	6.67	10.00	13.33	16.67	20.00	23.33	26.66	30.00	200.0	400.0	599.9	799.9	999.9
51	.32	.65	9.97	.30	.62	19.94	.27	.59	29.92	199.4	398.9	8.3	7.7	7.2
52	.31	.63	.95	.26	.58	.89	.20	.52	.84	8.9	7.8	6.7	5.6	4.5
53	.31	.61	.92	.22	.53	.84	.14	.45	.75	8.4	6.7	5.1	3.4	91.8
54	.30	.59	.89	.19	.49	.78	.08	.38	.67	7.8	5.6	3.5	91.3	89.1
83 55	3.29	6.58	9.86	13.15	16.44	19.73	23.01	26.30	29.59	197.3	394.6	591.8	789.1	986.4
56	.28	.56	.84	.11	.40	.67	2.95	.23	.51	6.7	3.5	90.2	7.0	3.7
57	.27	.54	.81	.08	.35	.62	.89	.16	.43	6.2	2.4	88.6	4.8	81.0
58	.26	.52	.78	.04	.31	.57	.83	.09	.35	5.7	1.3	7.0	2.7	78.3
59	.25	.50	.76	3.01	.26	.51	.76	6.02	.27	5.1	90.3	5.4	80.5	5.6
83 60	3.24	6.49	9.73	12.97	16.22	19.46	22.70	25.94	29.19	194.6	389.2	583.8	778.4	972.9

Lat.	Latitude 83° to 84°—Meridional arcs.						Latitude 83°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
83 00	31.023			1861.37					
1	3	1	31.02	.38	1	1 861.4	0 1	226.9	0.0
2	3	2	62.05	.38	2	3 722.7	2	453.7	0.1
3	3	3	93.07	.38	3	5 584.1	3	680.6	0.3
4	3	4	124.09	.38	4	7 445.5	4	907.5	0.5
83 05	31.023	5	155.12	1861.38	5	9 306.9	0 5	1 134.3	0.8
6	3	6	186.14	.38	6	11 168.3	6	1 361.2	1.2
7	3	7	217.16	.38	7	13 029.6	7	1 588.1	1.6
8	3	8	248.19	.38	8	14 891.0	8	1 814.9	2.1
9	3	9	279.21	.39	9	16 752.4	9	2 041.8	2.7
83 10	31.023	10	310.24	1861.39	10	18 613.8	0 10	2 268.7	3.3
11	3	1	341.26	.39	1	20 475.2	15	3 403.0	7.4
12	3	2	372.28	.39	2	22 336.6	20	4 537.3	13.1
13	3	3	403.31	.39	3	24 197.9	25	5 671.6	20.5
14	3	4	434.33	.39	4	26 059.3	30	6 805.9	29.5
83 15	31.023	15	465.35	1861.39	15	27 920.7	0 35	7 940.2	40.1
16	3	6	496.38	.39	6	29 782.1	40	9 074.5	52.4
17	3	7	527.40	.40	7	31 643.5	45	10 208.7	66.3
18	3	8	558.42	.40	8	33 504.9	50	11 343.0	81.9
19	3	9	589.45	.40	9	35 366.3	55	12 477.2	99.1
83 20	31.023	20	620.47	1861.40	20	37 227.7	1 00	13 611.4	117.9
21	3	1	651.49	.40	1	39 089.1	05	14 745.5	138.4
22	3	2	682.52	.40	2	40 950.5	10	15 879.6	160.5
23	3	3	713.54	.40	3	42 811.9	15	17 013.7	184.2
24	3	4	744.56	.40	4	44 673.3	20	18 147.8	209.6
83 25	31.023	25	775.59	1861.41	25	46 534.7	1 25	19 281.8	236.6
26	3	6	806.61	.41	6	48 396.1	30	20 415.8	265.3
27	3	7	837.64	.41	7	50 257.5	35	21 549.7	295.6
28	3	8	868.66	.41	8	52 118.9	40	22 683.6	327.5
29	4	9	899.68	.41	9	53 980.3	45	23 817.4	361.1
83 30	31.024	30	930.71	1861.41	30	55 841.7	1 50	24 951.2	396.3
31	4	1	961.73	.41	1	57 703.2	55	26 084.9	433.1
32	4	2	992.75	.41	2	59 564.6	2 00	27 219	472
33	4	3	1 023.78	.42	3	61 426.0	3 00	40 818	1 061
34	4	4	1 054.80	.42	4	63 287.4	4 00	54 405	1 886
83 35	31.024	35	1 085.82	1861.42	35	65 148.8	5 00	67 975	2 946
36	4	6	1 116.85	.42	6	67 010.2	6 00	81 525	4 241
37	4	7	1 147.87	.42	7	68 871.7	7 00	95 051	5 770
38	4	8	1 178.89	.42	8	70 733.1	8 00	108 548	7 534
39	4	9	1 209.92	.42	9	72 594.5	9 00	122 013	9 531
83 40	31.024	40	1 240.94	1861.42	40	74 455.9	10 00	135 441	11 761
41	4	1	1 271.96	.43	1	76 317.3	11 00	148 828	14 223
42	4	2	1 302.99	.43	2	78 178.8	12 00	162 171	16 917
43	4	3	1 334.01	.43	3	80 040.2	13 00	175 465	19 841
44	4	4	1 365.04	.43	4	81 901.6	14 00	188 706	22 996
83 45	31.024	45	1 396.06	1861.43	45	83 763.1	15 00	201 891	26 379
46	4	6	1 427.08	.43	6	85 624.5	16 00	215 015	29 990
47	4	7	1 458.11	.43	7	87 485.9	17 00	228 074	33 828
48	4	8	1 489.13	.43	8	89 347.4	18 00	241 065	37 892
49	4	9	1 520.15	.43	9	91 208.8	19 00	253 984	42 180
83 50	31.024	50	1 551.18	1861.44	50	93 070.2	20 00	266 827	46 691
51	4	1	1 582.20	.44	1	94 931.7	21 00	279 589	51 424
52	4	2	1 613.22	.44	2	96 793.1	22 00	292 268	56 377
53	4	3	1 644.25	.44	3	98 654.5	23 00	304 859	61 549
54	4	4	1 675.27	.44	4	100 516.0	24 00	317 358	66 939
83 55	31.024	55	1 706.29	1861.44	55	102 377.4	25 00	329 763	72 544
56	4	6	1 737.32	.44	6	104 238.9	26 00	342 068	78 363
57	4	7	1 768.34	.44	7	106 100.3	27 00	354 270	84 395
58	4	8	1 799.36	.45	8	107 961.8	28 00	366 367	90 637
59	4	9	1 830.39	.45	9	109 823.2	29 00	378 353	97 088
83 60	31.024	60	1 861.41	1861.45	60	111 684.7	30 00	390 226	103 745

Latitude 84° to 85°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
84 00	3.24	6.49	9.73	12.97	16.22	19.46	22.70	25.94	29.19	194.6	389.2	583.8	778.4	972.9
1	.23	.47	.70	.94	.17	.41	.64	.87	.11	4.1	8.1	2.2	6.2	70.3
2	.23	.45	.68	.90	.13	.35	.58	.80	9.03	3.5	7.0	80.5	4.0	67.6
3	.22	.43	.65	.86	.08	.30	.51	.73	8.95	3.0	5.9	78.9	71.9	4.9
4	.21	.41	.62	.83	6.04	.24	.45	.66	.87	2.4	4.9	7.3	69.7	62.2
84 05	3.20	6.40	9.59	12.79	15.99	9.19	22.39	25.59	28.78	191.9	383.8	575.7	767.6	959.5
6	.19	.38	.57	.76	6.95	.14	.33	.51	.70	1.4	2.7	4.1	5.4	6.8
7	.18	.36	.54	.72	.90	.08	.26	.44	.62	0.8	1.6	2.5	3.3	4.1
8	.17	.34	.51	.69	.86	9.03	.20	.37	.54	90.3	80.6	70.8	61.1	51.4
9	.16	.32	.49	.65	.81	8.97	.14	.30	.46	89.7	79.5	69.2	59.0	48.7
84 10	3.15	6.31	9.46	12.61	15.77	18.92	22.07	25.23	28.38	189.2	378.4	567.6	756.8	946.0
11	.14	.29	.43	.58	.72	.87	2.01	.15	.30	8.7	7.3	6.0	4.7	3.3
12	.14	.27	.41	.54	.68	.81	1.95	.08	.22	8.1	6.2	4.4	2.5	40.6
13	.13	.25	.38	.50	.63	.76	.88	5.01	.14	7.6	5.2	2.8	50.3	37.9
14	.12	.23	.35	.47	.59	.70	.82	4.94	8.06	7.0	4.1	61.1	48.2	5.2
84 15	3.11	6.22	9.33	12.43	15.54	18.65	21.76	24.87	27.97	186.5	373.0	559.5	746.0	932.5
16	.10	.20	.30	.40	.50	.60	.70	.79	.89	6.0	1.9	7.9	3.9	29.8
17	.09	.18	.27	.36	.45	.54	.63	.73	.82	5.4	70.9	6.3	41.7	7.2
18	.08	.16	.24	.33	.41	.49	.57	.65	.73	4.9	69.8	4.7	39.6	4.5
19	.07	.14	.22	.29	.36	.44	.51	.58	.65	4.4	8.7	3.1	7.4	21.8
84 20	3.06	6.13	9.19	12.25	15.32	18.38	21.45	24.51	27.57	183.8	367.6	551.4	735.3	919.1
21	.05	.11	.16	.22	.27	.33	.38	.44	.49	3.3	6.5	49.8	3.1	6.4
22	.05	.09	.14	.18	.23	.27	.32	.37	.41	2.7	5.5	8.2	30.9	3.7
23	.04	.07	.11	.14	.18	.22	.26	.29	.33	2.2	4.4	6.6	28.8	11.0
24	.03	.06	.08	.11	.14	.17	.19	.22	.25	1.7	3.3	5.0	6.6	08.3
84 25	3.02	6.04	9.06	12.07	15.09	18.11	21.13	24.15	27.17	181.1	362.2	543.4	724.5	905.6
26	.01	.02	.03	.04	.05	.06	.07	.08	.09	0.6	1.2	1.7	2.3	2.9
27	3.00	6.00	9.00	2.00	5.00	8.00	1.00	4.01	7.01	80.0	60.1	40.1	20.2	900.2
28	2.99	5.99	8.97	1.97	4.96	7.95	0.94	3.93	6.92	79.5	59.0	38.5	18.0	897.5
29	.98	.97	.95	.93	.91	.90	.88	.86	.84	9.0	7.9	6.9	5.9	4.8
84 30	2.97	5.95	8.92	11.89	14.87	17.84	20.82	23.79	26.76	178.4	356.8	535.3	713.7	892.1
31	.96	.93	.89	.86	.82	.79	.75	.72	.68	7.9	5.8	3.7	11.5	89.4
32	.96	.91	.87	.82	.78	.73	.69	.65	.60	7.3	4.7	2.0	09.4	6.7
33	.95	.89	.84	.79	.73	.68	.63	.57	.52	6.8	3.6	30.4	7.2	4.0
34	.94	.88	.81	.75	.69	.63	.56	.50	.44	6.3	2.5	28.8	5.1	81.3
84 35	2.93	5.86	8.79	11.71	14.64	17.57	20.50	23.43	26.36	175.7	351.4	527.2	702.9	878.6
36	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	50.4	5.7	700.8	6.0
37	.91	.82	.73	.65	.56	.47	.38	.29	.20	4.7	49.3	4.0	698.6	3.3
38	.90	.81	.71	.61	.51	.41	.32	.22	.12	4.1	8.2	2.3	6.5	70.6
39	.89	.79	.68	.57	.47	.36	.26	.15	6.04	3.6	7.1	20.7	4.3	67.9
84 40	2.88	5.77	8.65	11.54	14.42	17.30	20.19	23.07	25.96	173.0	346.1	519.1	692.1	865.2
41	.87	.75	.62	.50	.38	.25	.13	3.00	.88	2.5	5.0	7.5	90.0	62.5
42	.87	.73	.60	.46	.33	.20	.06	2.93	.79	2.0	3.9	5.9	87.8	59.8
43	.86	.71	.57	.43	.29	.14	20.00	.86	.71	1.4	2.8	4.3	5.7	7.1
44	.85	.70	.54	.39	.24	.09	19.94	.78	.63	0.9	1.8	2.6	3.5	4.4
84 45	2.84	5.68	8.52	11.36	14.20	17.03	19.87	22.71	25.55	170.3	340.7	511.0	681.4	851.7
46	.83	.66	.49	.32	.15	6.98	.81	.64	.47	69.8	39.6	09.4	79.2	49.0
47	.82	.64	.46	.28	.11	.93	.75	.57	.39	9.3	8.5	7.8	7.0	6.3
48	.81	.62	.44	.25	.06	.87	.68	.50	.31	8.7	7.4	6.2	4.9	3.6
49	.80	.61	.41	.21	4.02	.82	.62	.42	.23	8.2	6.4	4.5	2.7	40.9
84 50	2.79	5.59	8.38	11.18	13.97	16.76	19.56	22.35	25.15	167.6	335.3	502.9	670.6	838.2
51	.78	.57	.35	.14	.93	.71	.50	.28	5.07	7.1	4.2	501.3	68.4	5.5
52	.78	.55	.33	.10	.88	.66	.43	.21	4.98	6.6	3.1	499.7	6.3	2.8
53	.77	.53	.30	.07	.84	.60	.37	.14	.90	6.0	2.0	8.1	4.1	30.1
54	.76	.52	.27	.03	.79	.55	.31	2.06	.82	5.5	31.0	6.5	61.9	27.4
84 55	2.75	5.50	8.25	11.00	13.75	16.49	19.24	21.99	24.74	164.9	329.9	494.8	659.8	824.7
56	.74	.48	.22	0.96	.70	.44	.18	.92	.66	4.4	8.8	3.2	7.6	22.0
57	.73	.46	.19	.92	.66	.39	.12	.85	.58	3.9	7.7	1.6	5.5	19.3
58	.72	.44	.17	.89	.61	.33	9.05	.78	.50	3.3	6.7	90.0	3.3	6.6
59	.71	.43	.14	.85	.57	.28	8.99	.70	.42	2.8	5.6	88.4	51.2	3.9
84 60	2.70	5.41	8.11	10.82	13.52	16.22	18.93	21.63	24.34	162.2	324.5	486.7	649.0	811.2

Lat.	Latitude 84° to 85°—Meridional arcs.						Latitude 84°—Co-ordinates of curvature.		
	Value of 1''	Sums of seconds for middle latitude.		Value of 1'	Sums of minutes for middle latitude.		Longitude.	X	Y
° '	*Meters.*	''	*Meters.*	*Meters.*	'	*Meters.*	° '	*Meters.*	*Meters.*
84 00	31.024			1861.45					
1	4	1	31.02	.45	1	1 861.4	0 1	194.6	0.0
2	4	2	62.05	.45	2	3 722.9	2	389.2	0.1
3	4	3	93.07	.45	3	5 584.4	3	583.8	0.3
4	4	4	124.10	.45	4	7 445.8	4	778.3	0.5
84 05	31.024	5	155.12	1861.45	5	9 307.3	0 5	972.9	0.7
6	4	6	186.15	.45	6	11 168.7	6	1 167.5	1.0
7	4	7	217.17	.46	7	13 030.2	7	1 362.1	1.4
8	4	8	248.20	.46	8	14 891.6	8	1 556.7	1.8
9	4	9	279.22	.46	9	16 753.1	9	1 751.3	2.3
84 10	31.024	10	310.25	1861.46	10	18 614.5	0 10	1 945.9	2.8
11	4	1	341.27	.46	1	20 476.0	15	2 918.8	6.3
12	4	2	372.30	.46	2	22 337.5	20	3 891.8	11.3
13	4	3	403.32	.46	3	24 198.9	25	4 864.7	17.6
14	4	4	434.35	.46	4	26 060.4	30	5 837.6	25.3
84 15	31.024	15	465.37	1861.46	15	27 921.9	0 35	6 810.5	34.5
16	4	6	496.39	.47	6	29 783.3	40	7 783.4	45.0
17	4	7	527.42	.47	7	31 644.8	45	8 756.2	57.0
18	4	8	558.44	.47	8	33 506.3	50	9 729.1	70.4
19	4	9	589.47	.47	9	35 367.7	55	10 701.9	85.1
84 20	31.025	20	620.49	1861.47	20	37 229.2	1 00	11 674.7	101.3
21	5	1	651.52	.47	1	39 090.7	05	12 647.5	118.9
22	5	2	682.54	.47	2	40 952.1	10	13 620.3	137.9
23	5	3	713.57	.47	3	42 813.6	15	14 593.0	158.3
24	5	4	744.59	.47	4	44 675.1	20	15 565.7	180.1
84 25	31.025	25	775.62	1861.48	25	46 536.6	1 25	16 538.4	203.3
26	5	6	806.64	.48	6	48 398.0	30	17 511.0	228.0
27	5	7	837.67	.48	7	50 259.5	35	18 483.6	254.0
28	5	8	868.69	.48	8	52 121.0	40	19 456.2	281.5
29	5	9	899.72	.48	9	53 982.5	45	20 428.7	310.3
84 30	31.025	30	930.74	1861.48	30	55 844.0	1 50	21 401.2	340.6
31	5	1	961.77	.48	1	57 705.4	55	22 373.6	372.2
32	5	2	992.79	.48	2	59 566.9	2 00	23 346	405
33	5	3	1 023.81	.48	3	61 428.4	3 00	35 010	912
34	5	4	1 054.84	.49	4	63 289.9	4 00	46 664	1 621
84 35	31.025	35	1 085.86	1861.49	35	65 151.4	5 00	58 303	2 532
36	5	6	1 116.89	.49	6	67 012.9	6 00	69 925	3 644
37	5	7	1 147.91	.49	7	68 874.4	7 00	81 526	4 959
38	5	8	1 178.94	.49	8	70 735.9	8 00	93 103	6 475
39	5	9	1 209.96	.49	9	72 597.3	9 00	104 651	8 191
84 40	31.025	40	1 240.99	1861.49	40	74 458.8	10 00	116 168	10 107
41	5	1	1 272.01	.49	1	76 320.3	11 00	127 650	12 223
42	5	2	1 303.04	.49	2	78 181.8	12 00	139 093	14 539
43	5	3	1 334.06	.49	3	80 043.3	13 00	150 494	17 052
44	5	4	1 365.09	.50	4	81 904.8	14 00	161 851	19 763
84 45	31.025	45	1 396.11	1861.50	45	83 766.3	15 00	173 158	22 670
46	5	6	1 427.14	.50	6	85 627.8	16 00	184 413	25 774
47	5	7	1 458.16	.50	7	87 489.3	17 00	195 613	29 072
48	5	8	1 489.18	.50	8	89 350.8	18 00	206 753	32 564
49	5	9	1 520.21	.50	9	91 212.3	19 00	217 832	36 249
84 50	31.025	50	1 551.23	1861.50	50	93 073.8	20 00	228 845	40 126
51	5	1	1 582.26	.50	1	94 935.3	21 00	239 788	44 193
52	5	2	1 613.28	.50	2	96 796.8	22 00	250 660	48 450
53	5	3	1 644.31	.50	3	98 658.3	23 00	261 456	52 894
54	5	4	1 675.33	.51	4	100 519.8	24 00	272 173	57 526
84 55	31.025	55	1 706.36	1861.51	55	102 381.3	25 00	282 809	62 343
56	5	6	1 737.38	.51	6	104 242.8	26 00	293 359	67 343
57	5	7	1 768.41	.51	7	106 104.3	27 00	303 820	72 526
58	5	8	1 799.43	.51	8	107 965.9	28 00	314 190	77 890
59	5	9	1 830.46	.51	9	109 827.4	29 00	324 466	83 433
84 60	31.025	60	1 861.48	1861.51	60	111 688.9	30 00	334 644	89 153

Latitude 85° to 86°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
85 00	2.70	5.41	8.11	10.82	13.52	16.22	18.93	21.63	24.34	162.2	324.5	486.7	649.0	811.2
1	.70	.39	.09	.78	.48	.17	.87	.56	.26	1.7	3.4	5.1	6.8	08.6
2	.69	.37	.06	.75	.43	.12	.80	.49	.18	1.2	2.3	3.5	4.7	5.9
3	.68	.35	.03	.71	.39	.06	.74	.42	.10	0.6	1.3	1.9	2.5	3.2
4	.67	.34	8.00	.67	.34	6.01	.68	.35	4.02	60.1	20.2	80.3	40.4	800.5
85 05	2.66	5.32	7.98	10.64	13.30	15.96	18.62	21.27	23.93	159.6	319.1	478.7	638.2	797.8
6	.65	.30	.95	.60	.25	.90	.55	.20	.85	9.0	8.0	7.0	6.1	5.1
7	.64	.28	.92	.57	.21	.85	.49	.13	.77	8.5	7.0	5.4	3.9	92.4
8	.63	.26	.90	.53	.16	.79	.43	1.06	.69	7.9	5.9	3.8	31.7	89.7
9	.62	.25	.87	.49	.12	.74	.36	0.99	.61	7.4	4.8	2.2	29.6	7.0
85 10	2.61	5.23	7.84	10.46	13.07	15.69	18.30	20.91	23.53	156.9	313.7	470.6	627.4	784.3
11	.61	.21	.82	.42	3.03	.63	.24	.84	.45	6.3	2.6	68.9	5.3	81.6
12	.60	.19	.79	.39	2.98	.58	.17	.77	.37	5.8	1.6	7.3	3.1	78.9
13	.59	.17	.76	.35	.94	.52	.11	.70	.29	5.2	10.5	5.7	20.9	6.2
14	.58	.16	.73	.31	.89	.47	8.05	.63	.21	4.7	09.4	4.1	18.8	3.5
85 15	2.57	5.14	7.71	10.28	12.85	15.42	17.99	20.55	23.12	154.2	308.3	462.5	616.6	770.8
16	.56	.12	.68	.24	.80	.36	.92	.48	3.04	3.6	7.2	60.9	4.5	68.1
17	.55	.10	.65	.21	.76	.31	.86	.41	2.96	3.1	6.2	59.2	2.3	5.4
18	.54	.08	.63	.17	.71	.25	.80	.34	.88	2.5	5.1	7.6	10.2	2.7
19	.53	.07	.60	.13	.67	.20	.73	.27	.80	2.0	4.0	6.0	08.0	60.0
85 20	2.52	5.05	7.57	10.10	12.62	15.15	17.67	20.19	22.72	151.5	302.9	454.4	605.8	757.3
21	.52	.03	.55	.06	.58	.09	.61	.12	.64	0.9	1.8	2.8	3.7	4.6
22	.51	5.01	.52	10.03	.53	5.04	.54	20.05	.56	50.4	300.8	51.1	601.5	51.9
23	.50	4.99	.49	9.99	.49	4.98	.48	19.98	.48	49.8	299.7	49.5	599.4	49.2
24	.49	.98	.46	.95	.44	.93	.42	.91	.40	9.3	8.6	7.9	7.2	6.5
85 25	2.48	4.96	7.44	9.92	12.40	14.88	17.36	19.83	22.31	148.8	297.5	446.3	595.0	743.8
26	.47	.94	.41	.88	.35	.82	.29	.76	.23	8.2	6.4	4.7	2.9	41.1
27	.46	.92	.38	.85	.31	.77	.23	.69	.15	7.7	5.4	3.0	90.7	38.4
28	.45	.90	.36	.81	.26	.71	.17	.62	2.07	7.1	4.3	41.4	88.6	5.7
29	.44	.89	.33	.77	.22	.66	.10	.55	1.99	6.6	3.2	39.8	6.4	3.0
85 30	2.43	4.87	7.30	9.74	12.17	14.61	17.04	19.47	21.91	146.1	292.1	438.2	584.2	730.3
31	.43	.85	.28	.70	.13	.55	6.98	.40	.83	5.5	1.0	6.6	82.1	27.6
32	.42	.83	.25	.67	.08	.50	.91	.33	.75	5.0	90.0	4.9	79.9	4.9
33	.41	.81	.22	.63	2.04	.44	.85	.26	.67	4.4	88.9	3.3	7.8	22.2
34	.40	.80	.19	.59	1.99	.39	.79	.19	.59	3.9	7.8	1.7	5.6	19.5
85 35	2.39	4.78	7.17	9.56	11.95	14.34	16.73	19.11	21.50	143.4	286.7	430.1	573.4	716.8
36	.38	.76	.14	.52	.90	.28	.66	9.04	.42	2.8	5.6	28.5	71.3	4.1
37	.37	.74	.11	.49	.86	.23	.60	8.97	.34	2.3	4.6	6.8	69.1	11.4
38	.36	.72	.09	.45	.81	.17	.54	.90	.26	1.7	3.5	5.2	7.0	08.7
39	.35	.71	.06	.41	.77	.12	.47	.83	.18	1.2	2.4	3.6	4.8	6.0
85 40	2.34	4.69	7.03	9.38	11.72	14.07	16.41	18.75	21.10	140.7	281.3	422.0	562.6	703.3
41	.34	.67	7.01	.34	.68	4.01	.35	.68	1.02	40.1	80.2	20.4	60.5	700.6
42	.33	.65	6.98	.31	.63	3.96	.28	.61	0.94	39.6	79.2	18.7	58.3	697.9
43	.32	.63	.95	.27	.59	.90	.22	.54	.86	9.0	8.1	7.1	6.2	5.2
44	.31	.62	.92	.23	.54	.85	.16	.47	.78	8.5	7.0	5.5	4.0	92.5
85 45	2.30	4.60	6.90	9.20	11.50	13.80	16.10	18.39	20.69	138.0	275.9	413.9	551.8	689.8
46	.29	.58	.87	.16	.45	.74	6.03	.32	.61	7.4	4.8	2.3	49.7	7.1
47	.28	.56	.84	.13	.41	.69	5.97	.25	.53	6.9	3.8	10.6	7.5	4.4
48	.27	.54	.82	.09	.36	.63	.91	.18	.45	6.3	2.7	09.0	5.4	81.7
49	.26	.53	.79	.05	.32	.58	.84	.11	.37	5.8	1.6	7.4	3.2	79.0
85 50	2.25	4.51	6.76	9.02	11.27	13.53	15.78	18.03	20.29	135.3	270.5	405.8	541.0	676.3
51	.25	.49	.74	8.98	.23	.47	.72	7.96	.21	4.7	69.4	4.2	38.9	3.6
52	.24	.47	.71	.95	.18	.42	.65	.89	.13	4.2	8.4	2.5	6.7	70.9
53	.23	.45	.68	.91	.14	.36	.59	.82	20.05	3.6	7.3	400.9	4.6	68.2
54	.22	.44	.65	.87	.09	.31	.53	.75	19.97	3.1	6.2	399.3	2.4	5.5
85 55	2.21	4.42	6.63	8.84	11.05	13.26	15.46	17.67	19.88	132.6	265.1	397.7	530.2	662.8
56	.20	.40	.60	.80	1.00	.20	.40	.60	.80	2.0	4.0	6.1	28.1	60.1
57	.19	.38	.57	.77	0.96	.15	.34	.53	.72	1.5	3.0	4.4	5.9	57.4
58	.18	.36	.55	.73	.91	.09	.28	.46	.64	0.9	1.9	2.8	3.8	4.7
59	.17	.35	.52	.69	.87	3.04	.21	.39	.56	30.4	60.8	91.2	21.6	52.0
85 60	2.16	4.33	6.49	8.66	10.82	12.99	15.15	17.31	19.48	129.9	259.7	389.6	519.4	649.3

Lat.		Latitude 85° to 86°—Meridional arcs.						Latitude 85°—Co-ordinates of curvature.			
		Value of 1′	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.		X	Y
°	′	Meters.	″	Meters.	Meters.	′	Meters.	°	′	Meters.	Meters.
85	00	31.025			1861.51						
	1	5	1	31.03	.51	1	1 861.5	0	1	162.2	0.0
	2	5	2	62.05	.51	2	3 723.0		2	324.5	0.1
	3	5	3	93.08	.51	3	5 584.5		3	486.7	0.2
	4	5	4	124.10	.51	4	7 446.0		4	649.0	0.4
85	05	31.025	5	155.13	1861.52	5	9 307.6	0	5	811.2	0.6
	6	5	6	186.15	.52	6	11 169.1		6	973.5	0.8
	7	5	7	217.18	.52	7	13 030.6		7	1 135.7	1.1
	8	5	8	248.21	.52	8	14 892.1		8	1 298.0	1.5
	9	5	9	279.23	.52	9	16 753.6		9	1 460.2	1.9
85	10	31.025	10	310.26	1861.52	10	18 615.2	0	10	1 622.5	2.3
	11	5	1	341.28	.52	1	20 476.7		15	2 433.7	5.3
	12	5	2	372.31	.52	2	22 338.2		20	3 245.0	9.4
	13	5	3	403.33	.52	3	24 199.7		25	4 056.2	14.7
	14	5	4	434.36	.52	4	26 061.2		30	4 867.4	21.2
85	15	31.025	15	465.38	1861.53	15	27 922.8	0	35	5 678.6	28.8
	16	5	6	496.41	.53	6	29 784.3		40	6 489.8	37.6
	17	5	7	527.44	.53	7	31 645.8		45	7 301.0	47.6
	18	5	8	558.46	.53	8	33 507.3		50	8 112.2	58.8
	19	5	9	589.49	.53	9	35 368.9		55	8 923.3	71.1
85	20	31.025	20	620.51	1861.53	20	37 230.4	1	00	9 734.5	84.6
	21	6	1	651.54	.53	1	39 091.9		05	10 545.6	99.3
	22	6	2	682.56	.53	2	40 953.5		10	11 356.7	115.2
	23	6	3	713.59	.53	3	42 815.0		15	12 167.8	132.2
	24	6	4	744.62	.53	4	44 676.5		20	12 978.8	150.4
85	25	31.026	25	775.64	1861.53	25	46 538.1	1	25	13 789.8	169.8
	26	6	6	806.67	.54	6	48 399.6		30	14 600.8	190.4
	27	6	7	837.69	.54	7	50 261.1		35	15 411.8	212.2
	28	6	8	868.72	.54	8	52 122.7		40	16 222.7	235.1
	29	6	9	899.74	.54	9	53 984.2		45	17 033.6	259.2
85	30	31.026	30	930.77	1861.54	30	55 845.7	1	50	17 844.5	284.4
	31	6	1	961.79	.54	1	57 707.3		55	18 655.3	310.9
	32	6	2	992.82	.54	2	59 568.8	2	00	19 466	338
	33	6	3	1 023.85	.54	3	61 430.4	3	00	29 192	762
	34	6	4	1 054.87	.54	4	63 291.9	4	00	38 909	1 354
85	35	31.026	35	1 085.90	1861.54	35	65 153.4	5	00	48 613	2 114
	36	6	6	1 116.92	.54	6	67 015.0	6	00	58 304	3 044
	37	6	7	1 147.95	.54	7	68 876.5	7	00	67 977	4 142
	38	6	8	1 178.97	.55	8	70 738.1	8	00	77 629	5 408
	39	6	9	1 210.00	.55	9	72 599.6	9	00	87 258	6 841
85	40	31.026	40	1 241.03	1861.55	40	74 461.2	10	00	96 860	8 442
	41	6	1	1 272.05	.55	1	76 322.7	11	00	106 433	10 209
	42	6	2	1 303.08	.55	2	78 184.3	12	00	115 974	12 143
	43	6	3	1 334.10	.55	3	80 045.8	13	00	125 480	14 242
	44	6	4	1 365.13	.55	4	81 907.4	14	00	134 948	16 506
85	45	31.026	45	1 396.15	1861.55	45	83 768.9	15	00	144 375	18 934
	46	6	6	1 427.18	.55	6	85 630.5	16	00	153 759	21 526
	47	6	7	1 458.21	.55	7	87 492.0	17	00	163 096	24 281
	48	6	8	1 489.23	.55	8	89 353.6	18	00	172 383	27 197
	49	6	9	1 520.26	.55	9	91 215.2	19	00	181 619	30 275
85	50	31.026	50	1 551.28	1861.56	50	93 076.7	20	00	190 800	33 512
	51	6	1	1 582.31	.56	1	94 938.3	21	00	199 922	36 909
	52	6	2	1 613.33	.56	2	96 799.8	22	00	208 985	40 464
	53	6	3	1 644.36	.56	3	98 661.4	23	00	217 985	44 176
	54	6	4	1 675.38	.56	4	100 522.9	24	00	226 918	48 044
85	55	31.026	55	1 706.41	1861.56	55	102 384.5	25	00	235 783	52 066
	56	6	6	1 737.44	.56	6	104 246.1	26	00	244 577	56 243
	57	6	7	1 768.46	.56	7	106 107.6	27	00	253 296	60 571
	58	6	8	1 799.49	.56	8	107 969.2	28	00	261 939	65 050
	59	6	9	1 830.51	.56	9	109 830.8	29	00	270 503	69 679
85	60	31.026	60	1 861.54	1861.56	60	111 692.3	30	00	278 986	74 456

Latitude 86° to 87°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
86 00	2.16	4.33	6.49	8.66	10.82	12.99	15.15	17.31	19.48	129.9	259.7	389.6	519.4	649.3
1	.16	.31	.47	.62	.78	.93	.09	.24	.40	9.3	8.6	8.0	7.3	6.6
2	.15	.29	.44	.59	.73	.88	5.02	.17	.32	8.8	7.6	6.3	5.1	3.9
3	.14	.27	.41	.55	.69	.82	4.96	.10	.24	8.2	6.5	4.7	3.0	41.2
4	.13	.26	.38	.51	.64	.77	.90	7.03	.16	7.7	5.4	3.1	10.8	38.5
86 05	2.12	4.24	6.36	8.48	10.60	12.72	14.83	16.95	19.07	127.2	254.3	381.5	508.6	635.8
6	.11	.22	.33	.44	.55	.66	.77	.88	8.99	6.6	3.2	79.9	6.5	3.1
7	.10	.20	.30	.41	.51	.61	.71	.81	.91	6.1	2.2	8.2	4.3	30.4
8	.09	.18	.28	.37	.46	.55	.65	.74	.83	5.5	1.1	6.6	2.2	27.7
9	.08	.17	.25	.33	.42	.50	.58	.67	.75	5.0	50.0	5.0	500.0	5.0
86 10	2.07	4.15	6.22	8.30	10.37	12.45	14.52	16.59	18.67	124.5	248.9	373.4	497.8	622.3
11	.07	.13	.20	.26	.33	.39	.46	.52	.59	3.9	7.8	1.8	5.7	19.6
12	.06	.11	.17	.23	.28	.34	.39	.45	.51	3.4	6.8	70.1	3.5	6.9
13	.05	.09	.14	.19	.24	.28	.33	.38	.43	2.8	5.7	68.5	91.3	4.2
14	.04	.08	.11	.15	.19	.23	.27	.31	.35	2.3	4.6	6.9	89.2	11.5
86 15	2.03	4.06	6.09	8.12	10.15	12.18	14.20	16.23	18.26	121.8	243.5	365.3	487.0	608.8
16	.02	.04	.06	.08	.10	.12	.14	.16	.18	1.2	2.4	3.6	4.9	6.1
17	.01	.02	.03	.05	.06	.07	.08	.09	.10	0.7	1.3	2.0	2.7	3.4
18	2.00	4.00	6.01	8.01	10.01	2.01	4.02	6.02	8.02	20.1	40.3	60.4	80.5	600.7
19	1.99	3.99	5.98	7.97	9.97	1.96	3.95	5.95	7.94	19.6	39.2	58.8	78.4	598.0
86 20	1.98	3.97	5.95	7.94	9.92	11.91	13.89	15.87	17.86	119.1	238.1	357.2	476.2	595.3
21	.98	.95	.93	.90	.88	.85	.83	.80	.78	8.5	7.0	5.5	4.0	92.6
22	.97	.93	.90	.87	.83	.80	.76	.73	.70	8.0	5.9	3.9	71.9	89.9
23	.96	.91	.87	.83	.79	.74	.70	.66	.62	7.4	4.9	2.3	69.7	7.2
24	.95	.90	.84	.79	.74	.69	.64	.59	.54	6.9	3.8	50.7	7.6	4.5
86 25	1.94	3.88	5.82	7.76	9.70	11.64	13.58	15.51	17.45	116.4	232.7	349.1	465.4	581.8
26	.93	.86	.79	.72	.65	.58	.51	.44	.37	5.8	1.6	7.4	3.2	79.0
27	.92	.84	.76	.68	.61	.53	.45	.37	.29	5.3	30.5	5.8	61.1	6.3
28	.91	.82	.74	.65	.56	.47	.38	.30	.21	4.7	29.5	4.2	58.9	3.6
29	.90	.81	.71	.61	.52	.42	.32	.22	.13	4.2	8.4	2.6	6.8	70.9
86 30	1.89	3.79	5.68	7.58	9.47	11.36	13.26	15.15	17.05	113.6	227.3	340.9	454.6	568.2
31	.88	.77	.65	.54	.43	.31	.20	.08	6.97	3.1	6.2	39.3	2.4	5.5
32	.87	.75	.63	.50	.38	.26	.13	5.01	.88	2.6	5.1	7.7	50.3	2.8
33	.86	.73	.60	.47	.34	.20	.07	4.94	.80	2.0	4.1	6.1	48.1	60.1
34	.86	.72	.57	.43	.29	.15	3.01	.86	.72	1.5	3.0	4.5	5.9	57.4
86 35	1.85	3.70	5.55	7.40	9.25	11.09	12.94	14.79	16.64	110.9	221.9	332.8	443.8	554.7
36	.84	.68	.52	.36	.20	1.04	.88	.72	.56	10.4	20.8	31.2	41.6	52.0
37	.83	.66	.49	.32	.16	0.99	.82	.65	.48	09.9	19.7	29.6	39.5	49.3
38	.82	.64	.47	.29	.11	.93	.75	.58	.40	9.3	8.6	8.0	7.3	6.6
39	.81	.63	.44	.25	.07	.88	.69	.50	.32	8.8	7.6	6.3	5.1	3.9
86 40	1.80	3.61	5.41	7.22	9.02	10.82	12.63	14.43	16.24	108.2	216.5	324.7	433.0	541.2
41	.79	.59	.38	.18	8.98	.77	.57	.36	.16	7.7	5.4	3.1	30.8	38.5
42	.79	.57	.36	.14	.93	.72	.50	.29	6.07	7.2	4.3	21.5	28.6	5.8
43	.78	.55	.33	.11	.89	.66	.44	.22	5.99	6.6	3.2	19.9	6.5	3.1
44	.77	.54	.30	.07	.84	.61	.38	.14	.92	6.1	2.2	8.2	4.3	30.4
86 45	1.76	3.52	5.28	7.04	8.80	10.55	12.31	14.07	15.83	105.5	211.1	316.6	422.2	527.7
46	.75	.50	.25	7.00	.75	.50	.25	4.00	.75	5.0	10.0	5.0	20.0	5.0
47	.74	.48	.22	6.96	.71	.45	.19	3.93	.67	4.5	08.9	3.4	17.8	22.3
48	.73	.46	.20	.93	.66	.39	.12	.86	.59	3.9	7.8	1.8	5.7	19.6
49	.72	.45	.17	.89	.62	.34	.06	.78	.51	3.4	6.8	10.1	3.5	6.9
86 50	1.71	3.43	5.14	6.86	8.57	10.28	12.00	13.71	15.43	102.8	205.7	308.5	411.3	514.2
51	.70	.41	.11	.82	.53	.23	1.94	.64	.35	2.3	4.6	6.9	09.2	11.5
52	.70	.39	.09	.78	.48	.18	.87	.57	.26	1.8	3.5	5.3	7.0	08.8
53	.69	.37	.06	.75	.44	.12	.81	.50	.18	1.2	2.4	3.6	4.9	6.1
54	.68	.36	.03	.71	.39	.07	.75	.42	.10	0.7	1.3	2.0	2.7	3.4
86 55	1.67	3.34	5.01	6.68	8.35	10.01	11.68	13.35	15.02	100.1	200.3	300.4	400.5	500.7
56	.66	.32	4.98	.64	.30	9.96	.62	.28	4.94	99.6	199.2	298.8	398.4	498.0
57	.65	.30	.95	.60	.26	.91	.56	.21	.86	9.1	8.1	7.2	6.2	5.3
58	.64	.28	.93	.57	.21	.85	.49	.14	.78	8.5	7.0	5.5	4.0	92.6
59	.63	.27	.90	.53	.17	.80	.43	3.06	.70	8.0	5.9	3.9	1.9	89.9
86 60	1.62	3.25	4.87	6.50	8.12	9.74	11.37	12.99	14.61	97.4	194.9	292.3	389.7	487.2

Lat.	Latitude 86° to 87°—Meridional arcs.						Latitude 86°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
86 00	31.026			1861.56					
1	6	1	31.03	.56	1	1 861.6	0 1	129.9	0.0
2	6	2	62.05	.56	2	3 723.1	2	259.7	0.1
3	6	3	93.08	.57	3	5 584.7	3	389.6	0.2
4	6	4	124.11	.57	4	7 446.3	4	519.4	0.3
86 05	31.026	5	155.13	1861.57	5	9 307.8	0 5	649.3	0.5
6	6	6	186.16	.57	6	11 169.4	6	779.2	0.7
7	6	7	217.18	.57	7	13 031.0	7	909.0	0.9
8	6	8	248.21	.57	8	14 892.5	8	1 038.9	1.2
9	6	9	279.24	.57	9	16 754.1	9	1 168.7	1.5
86 10	31.026	10	310.26	1861.57	10	18 615.7	0 10	1 298.6	1.9
11	6	1	341.29	.57	1	20 477.2	15	1 947.9	4.2
12	6	2	372.32	.57	2	22 338.8	20	2 597.2	7.5
13	6	3	403.34	.57	3	24 200.4	25	3 246.5	11.8
14	6	4	434.37	.57	4	26 062.0	30	3 895.8	17.0
86 15	31.026	15	465.40	1861.57	15	27 923.5	0 35	4 545.0	23.1
16	6	6	496.42	.58	6	29 785.1	40	5 194.3	30.1
17	6	7	527.45	.58	7	31 646.7	45	5 843.6	38.1
18	6	8	558.48	.58	8	33 508.3	50	6 492.8	47.1
19	6	9	589.50	.58	9	35 369.8	55	7 142.0	57.0
86 20	31.026	20	620.53	1861.58	20	37 231.4	1 00	7 791.2	67.8
21	6	1	651.55	.58	1	39 093.0	05	8 440.4	79.6
22	6	2	682.58	.58	2	40 954.6	10	9 089.6	92.3
23	6	3	713.61	.58	3	42 816.2	15	9 738.8	106.0
24	6	4	744.63	.58	4	44 677.7	20	10 387.9	120.6
86 25	31.026	25	775.66	1861.58	25	46 539.3	1 25	11 037.0	136.1
26	6	6	806.69	.58	6	48 400.9	30	11 686.1	152.6
27	6	7	837.71	.58	7	50 262.5	35	12 335.2	170.0
28	6	8	868.74	.58	8	52 124.1	40	12 984.2	188.4
29	6	9	899.77	.58	9	53 985.7	45	13 633.2	207.7
86 30	31.026	30	930.79	1861.58	30	55 847.2	1 50	14 282.2	228.0
31	6	1	961.82	.59	1	57 708.8	55	14 931.2	249.2
32	6	2	992.85	.59	2	59 570.4	2 00	15 580	271
33	6	3	1 023.87	.59	3	61 432.0	3 00	23 364	610
34	6	4	1 054.90	.59	4	63 293.6	4 00	31 141	1 085
86 35	31.026	35	1 085.92	1861.59	35	65 155.2	5 00	38 909	1 695
36	6	6	1 116.95	.59	6	67 016.8	6 00	46 665	2 440
37	6	7	1 147.98	.59	7	68 878.3	7 00	54 406	3 320
38	6	8	1 179.00	.59	8	70 739.9	8 00	62 132	4 334
39	6	9	1 210.03	.59	9	72 601.5	9 00	69 838	5 483
86 40	31.027	40	1 241.06	1861.59	40	74 463.1	10 00	77 523	6 766
41	7	1	1 272.08	.59	1	76 324.7	11 00	85 185	8 182
42	7	2	1 303.11	.59	2	78 186.3	12 00	92 821	9 732
43	7	3	1 334.14	.59	3	80 047.9	13 00	100 428	11 414
44	7	4	1 365.16	.59	4	81 909.5	14 00	108 006	13 229
86 45	31.027	45	1 396.19	1861.59	45	83 771.1	15 00	115 550	15 175
46	7	6	1 427.21	.60	6	85 632.7	16 00	123 060	17 252
47	7	7	1 458.24	.60	7	87 494.3	17 00	130 532	19 460
48	7	8	1 489.27	.60	8	89 355.9	18 00	137 965	21 797
49	7	9	1 520.29	.60	9	91 217.5	19 00	145 356	24 264
86 50	31.027	50	1 551.32	1861.60	50	93 079.1	20 00	152 702	26 859
51	7	1	1 582.35	.60	1	94 940.7	21 00	160 003	29 581
52	7	2	1 613.37	.60	2	96 802.3	22 00	167 255	32 430
53	7	3	1 644.40	.60	3	98 663.9	23 00	174 456	35 405
54	7	4	1 675.43	.60	4	100 525.5	24 00	181 604	38 504
86 55	31.027	55	1 706.45	1861.60	55	102 387.1	25 00	188 698	41 728
56	7	6	1 737.48	.60	6	104 248.7	26 00	195 734	45 075
57	7	7	1 768.51	.60	7	106 110.3	27 00	202 711	48 543
58	7	8	1 799.53	.60	8	107 971.9	28 00	209 626	52 133
59	7	9	1 830.56	.60	9	109 833.5	29 00	216 478	55 843
86 60	31.027	60	1 861.58	1861.60	60	111 695.1	30 00	223 264	59 671

Latitude 87° to 88°—Arcs of the parallel in meters.

Lat.	1″	″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
87 00	1.62	3.25	4.87	6.50	8.12	9.74	11.37	12.99	14.61	97.4	194.9	292.3	389.7	487.2
1	.61	.23	.84	.46	.08	.69	.31	.92	.53	6.9	3.8	90.7	7.6	4.5
2	.61	.21	.82	.42	8.03	.63	.24	.85	.45	6.3	2.7	89.0	5.4	81.7
3	.60	.19	.79	.39	7.98	.58	.18	.77	.37	5.8	1.6	7.4	3.2	79.0
4	.59	.18	.76	.35	.94	.53	.11	.70	.29	5.3	90.5	5.8	81.1	6.3
87 05	1.58	3.16	4.74	6.31	7.89	9.47	11.05	12.63	14.21	94.7	189.5	284.2	378.9	473.6
6	.57	.14	.71	.28	.85	.42	0.99	.56	.13	4.2	8.4	2.6	6.7	70.9
7	.56	.12	.68	.24	.80	.36	.92	.49	4.05	3.6	7.3	80.9	4.6	68.2
8	.55	.10	.65	.21	.76	.31	.86	.41	3.96	3.1	6.2	79.3	2.4	5.5
9	.54	.09	.63	.17	.71	.26	.80	.34	.88	2.6	5.1	7.7	70.3	2.8
87 10	1.53	3.07	4.60	6.13	7.67	9.20	10.74	12.27	13.80	92.0	184.0	276.1	368.1	460.1
11	.52	.05	.57	.10	.62	.15	.67	.20	.72	1.5	3.0	4.4	5.9	57.4
12	.52	.03	.55	.06	.58	.09	.61	.13	.64	0.9	1.9	2.8	3.8	4.7
13	.51	.01	.52	6.03	.53	9.04	.55	2.05	.56	90.4	80.8	71.2	61.6	52.0
14	.50	3.00	.49	5.99	.49	8.99	.48	1.98	.48	89.9	79.7	69.6	59.4	49.3
87 15	1.49	2.98	4.47	5.95	7.44	8.93	10.42	11.91	13.40	89.3	178.6	268.0	357.3	446.6
16	.48	.96	.44	.92	.40	.88	.36	.84	.32	8.8	7.6	6.3	5.1	3.9
17	.47	.94	.41	.88	.35	.82	.29	.77	.24	8.2	6.5	4.7	3.0	41.2
18	.46	.92	.38	.85	.31	.77	.23	.69	.15	7.7	5.4	3.1	50.8	38.5
19	.45	.91	.36	.81	.26	.72	.17	.62	3.07	7.2	4.3	61.5	48.6	5.8
87 20	1.44	2.89	4.33	5.77	7.22	8.66	10.11	11.55	12.99	86.6	173.2	259.8	346.5	433.1
21	.43	.87	.30	.74	.17	.61	10.04	.48	.91	6.1	2.1	8.2	4.3	30.4
22	.43	.85	.28	.70	.13	.55	9.98	.41	.83	5.5	1.1	6.6	2.1	27.7
23	.42	.83	.25	.67	.08	.50	.92	.33	.75	5.0	70.0	5.0	40.0	5.0
24	.41	.82	.22	.63	7.04	.45	.85	.26	.67	4.5	68.9	3.4	37.8	22.3
87 25	1.40	2.80	4.20	5.59	6.99	8.39	9.79	11.19	12.59	83.9	167.8	251.7	335.6	419.6
26	.39	.78	.17	.56	.95	.34	.73	.12	.50	3.4	6.7	50.1	3.5	6.8
27	.38	.76	.14	.52	.90	.28	.66	1.05	.42	2.8	5.7	48.5	31.3	4.1
28	.37	.74	.11	.49	.86	.23	.60	0.97	.34	2.3	4.6	6.9	29.2	11.4
29	.36	.72	.09	.45	.81	.17	.54	.90	.26	1.7	3.5	5.2	7.0	08.7
87 30	1.35	2.71	4.06	5.41	6.77	8.12	9.47	10.83	12.18	81.2	162.4	243.6	324.8	406.0
31	.34	.69	.03	.38	.72	.07	.41	.76	.10	0.7	1.3	2.0	2.7	3.3
32	.34	.67	4.01	.34	.68	8.01	.35	.69	2.02	80.1	60.2	40.4	20.5	400.6
33	.33	.65	3.98	.31	.63	7.96	.28	.61	1.94	79.6	59.2	38.7	18.3	397.9
34	.32	.63	.95	.27	.58	.90	.22	.54	.86	9.0	8.1	7.1	6.2	5.2
87 35	1.31	2.62	3.93	5.23	6.54	7.85	9.16	10.47	11.77	78.5	157.0	235.5	314.0	392.5
36	.30	.60	.90	.20	.50	.80	.10	.40	.69	8.0	5.0	3.9	11.8	89.8
37	.29	.58	.87	.16	.45	.74	9.03	.33	.61	7.4	4.8	2.3	09.7	7.1
38	.28	.56	.84	.13	.41	.69	8.97	.25	.53	6.9	3.8	30.6	7.5	4.4
39	.27	.54	.82	.09	.36	.63	.91	.18	.45	6.3	2.7	29.0	5.3	81.7
87 40	1.26	2.53	3.79	5.05	6.32	7.58	8.84	10.11	11.37	75.8	151.6	227.4	303.2	379.0
41	.25	.51	.76	5.02	.27	.53	.78	10.03	.29	5.3	50.5	5.8	301.0	6.3
42	.25	.49	.74	4.98	.23	.47	.72	9.96	.21	4.7	49.4	4.1	298.8	3.6
43	.24	.47	.71	.95	.18	.42	.65	.89	.13	4.2	8.3	2.5	6.7	70.9
44	.23	.45	.68	.91	.14	.36	.59	.82	1.05	3.6	7.3	20.9	4.5	68.1
87 45	1.22	2.44	3.65	4.87	6.09	7.31	8.53	9.74	10.96	73.1	146.2	219.3	292.4	365.4
46	.21	.42	.63	.84	.05	.26	.46	.67	.88	2.6	5.1	7.6	90.2	2.7
47	.20	.40	.60	.80	6.00	.20	.40	.60	.80	2.0	4.0	6.0	88.0	60.0
48	.19	.38	.57	.76	5.96	.15	.34	.53	.72	1.5	2.9	4.4	5.9	57.3
49	.18	.36	.55	.73	.91	.09	.27	.46	.64	0.9	1.8	2.8	3.7	4.6
87 50	1.17	2.35	3.52	4.69	5.87	7.04	8.21	9.38	10.56	70.4	140.8	211.1	281.5	351.9
51	.16	.33	.49	.66	.82	6.98	.15	.31	.48	69.8	39.7	09.5	79.4	49.2
52	.15	.31	.47	.62	.78	.93	.08	.24	.39	9.3	8.6	7.9	7.2	6.5
53	.15	.29	.44	.58	.73	.88	8.02	.17	.31	8.8	7.5	6.3	5.0	3.8
54	.14	.27	.41	.55	.69	.82	7.96	.10	.23	8.2	6.4	4.7	2.9	41.1
87 55	1.13	2.26	3.38	4.51	5.64	6.77	7.90	9.02	10.15	67.7	135.4	203.0	270.7	338.4
56	.12	.24	.36	.48	.60	.71	.83	8.95	10.07	7.1	4.3	201.4	68.5	5.7
57	.11	.22	.33	.44	.55	.66	.77	.88	9.99	6.6	3.2	199.8	6.4	3.0
58	.10	.20	.30	.40	.50	.61	.71	.81	.91	6.1	2.1	8.2	4.2	30.3
59	.09	.18	.28	.37	.46	.55	.64	.74	.83	5.5	31.0	6.5	62.0	27.6
87 60	1.08	2.17	3.25	4.33	5.41	6.50	7.58	8.66	9.75	65.0	129.9	194.9	259.9	324.9

Lat.	Latitude 87° to 88°—Meridional arcs.						Latitude 87°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	Meters.	″	Meters.	Meters.	′	Meters.	° ′	Meters.	Meters.
87 00	31.027			1861.60					
1	7	1	31.03	.60	1	1 861.6	0 1	97.4	0.0
2	7	2	62.05	.60	2	3 723.2	2	194.9	0.1
3	7	3	93.08	.61	3	5 584.8	3	292.3	0.1
4	7	4	124.11	.61	4	7 446.4	4	389.7	0.2
87 05	31.027	5	155.13	1861.61	5	9 308.0	0 5	487.2	0.4
6	7	6	186.16	.61	6	11 169.6	6	584.6	0.5
7	7	7	217.19	.61	7	13 031.2	7	682.0	0.7
8	7	8	248.22	.61	8	14 892.9	8	779.5	0.9
9	7	9	279.24	.61	9	16 754.5	9	876.9	1.1
87 10	31.027	10	310.27	1861.61	10	18 616.1	0 10	974.3	1.4
11	7	1	341.30	.61	1	20 477.7	15	1 461.5	3.2
12	7	2	372.32	.61	2	22 339.3	20	1 948.6	5.7
13	7	3	403.35	.61	3	24 200.9	25	2 435.7	8.8
14	7	4	434.38	.61	4	26 062.5	30	2 922.9	12.7
87 15	31.027	15	465.40	1861.61	15	27 924.1	0 35	3 410.0	17.3
16	7	6	496.43	.61	6	29 785.7	40	3 897.1	22.7
17	7	7	527.46	.61	7	31 647.4	45	4 384.3	28.7
18	7	8	558.49	.61	8	33 509.0	50	4 871.4	35.4
19	7	9	589.51	.61	9	35 370.6	55	5 358.5	42.8
87 20	31.027	20	620.54	1861.61	20	37 232.2	1 00	5 845.5	50.9
21	7	1	651.57	.62	1	39 093.8	05	6 332.6	59.8
22	7	2	682.59	.62	2	40 955.4	10	6 819.7	69.3
23	7	3	713.62	.62	3	42 817.0	15	7 306.7	79.6
24	7	4	744.65	.62	4	44 678.7	20	7 793.7	90.6
87 25	31.027	25	775.67	1861.62	25	46 540.3	1 25	8 280.8	102.2
26	7	6	806.70	.62	6	48 401.9	30	8 767.8	114.6
27	7	7	837.73	.62	7	50 263.5	35	9 254.7	127.7
28	7	8	868.76	.62	8	52 125.1	40	9 741.7	141.5
29	7	9	899.78	.62	9	53 986.8	45	10 228.6	156.0
87 30	31.027	30	930.81	1861.62	30	55 848.4	1 50	10 715.5	171.2
31	7	1	961.84	.62	1	57 710.0	55	11 202.4	187.1
32	7	2	992.86	.62	2	59 571.6	2 00	11 689	204
33	7	3	1 023.89	.62	3	61 433.2	3 00	17 529	459
34	7	4	1 054.92	.62	4	63 294.8	4 00	23 364	815
87 35	31.027	35	1 085.94	1861.62	35	65 156.5	5 00	29 192	1 273
36	7	6	1 116.97	.62	6	67 018.1	6 00	35 011	1 832
37	7	7	1 148.00	.62	7	68 879.7	7 00	40 819	2 493
38	7	8	1 179.03	.62	8	70 741.3	8 00	46 615	3 255
39	7	9	1 210.05	.62	9	72 603.0	9 00	52 397	4 118
87 40	31.027	40	1 241.08	1861.62	40	74 464.6	10 00	58 163	5 082
41	7	1	1 272.11	.62	1	76 326.2	11 00	63 911	6 145
42	7	2	1 303.13	.63	2	78 187.8	12 00	69 640	7 309
43	7	3	1 334.16	.63	3	80 049.5	13 00	75 347	8 573
44	7	4	1 365.19	.63	4	81 911.1	14 00	81 032	9 936
87 45	31.027	45	1 396.21	1861.63	45	83 772.7	15 00	86 692	11 397
46	7	6	1 427.24	.63	6	85 634.3	16 00	92 326	12 958
47	7	7	1 458.27	.63	7	87 496.0	17 00	97 932	14 616
48	7	8	1 489.30	.63	8	89 357.6	18 00	103 507	16 371
49	7	9	1 520.32	.63	9	91 219.2	19 00	109 052	18 223
87 50	31.027	50	1 551.35	1861.63	50	93 080.9	20 00	114 563	20 172
51	7	1	1 582.38	.63	1	94 942.5	21 00	120 040	22 217
52	7	2	1 613.40	.63	2	96 804.1	22 00	125 480	24 357
53	7	3	1 644.43	.63	3	98 665.7	23 00	130 882	26 591
54	7	4	1 675.46	.63	4	100 527.4	24 00	136 244	28 919
87 55	31.027	55	1 706.48	1861.63	55	102 389.0	25 00	141 565	31 340
56	7	6	1 737.51	.63	6	104 250.6	26 00	146 843	33 853
57	7	7	1 768.54	.63	7	106 112.3	27 00	152 076	36 458
58	7	8	1 799.57	.63	8	107 973.9	28 00	157 263	39 154
59	7	9	1 830.59	.63	9	109 835.5	29 00	162 402	41 940
87 60	31.027	60	1 861.62	1861.63	60	111 697.2	30 00	167 492	44 815

Latitude 88° to 89°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
88 00	1.08	2.17	3.25	4.33	5.41	6.50	7.58	8.66	9.75	65.0	129.9	194.9	259.9	324.9
1	.07	.15	.22	.29	.37	.44	.52	.59	.66	4.4	8.9	3.3	7.7	22.1
2	.06	.13	.19	.26	.32	.39	.45	.52	.58	3.9	7.8	1.7	5.5	19.4
3	.06	.11	.17	.22	.28	.33	.39	.45	.50	3.3	6.7	90.0	3.4	6.7
4	.05	.09	.14	.19	.23	.28	.33	.37	.42	2.8	5.6	88.4	51.2	4.0
88 05	1.04	2.08	3.11	4.15	5.19	6.23	7.26	8.30	9.34	62.3	124.5	186.8	249.1	311.3
6	.03	.06	.09	.11	.14	.17	.20	.23	.26	1.7	3.4	5.2	6.9	08.6
7	.02	.04	.06	.08	.10	.12	.14	.16	.18	1.2	2.4	3.5	4.7	5.9
8	.01	.02	.03	.04	.05	.06	.07	.09	.10	0.6	1.3	1.9	2.6	3.2
9	1.00	2.00	3.01	4.01	5.01	6.01	7.01	8.01	9.01	60.1	20.2	80.3	40.4	300.5
88 10	0.99	1.99	2.98	3.97	4.96	5.96	6.95	7.94	8.93	59.6	119.1	178.7	238.2	297.8
11	.98	.97	.95	.93	.92	.90	.89	.87	.85	9.0	8.0	7.0	6.1	5.1
12	.97	.95	.92	.90	.87	.85	.82	.80	.77	8.5	6.9	5.4	3.9	92.4
13	.97	.93	.90	.86	.83	.79	.76	.73	.69	7.9	5.9	3.8	31.7	89.7
14	.96	.91	.87	.83	.78	.74	.70	.65	.61	7.4	4.8	2.2	29.6	7.0
88 15	0.95	1.90	2.84	3.79	4.74	5.69	6.63	7.58	8.53	56.9	113.7	170.6	227.4	284.3
16	.94	.88	.82	.75	.69	.63	.57	.51	.45	6.3	2.6	68.9	5.2	81.5
17	.93	.86	.79	.72	.65	.58	.51	.43	.36	5.8	1.5	7.3	3.1	78.8
18	.92	.84	.76	.68	.60	.52	.44	.36	.28	5.2	10.5	5.7	20.9	6.1
19	.91	.82	.73	.65	.56	.47	.38	.29	.20	4.7	09.4	4.1	18.7	3.4
88 20	0.90	1.80	2.71	3.61	4.51	5.41	6.32	7.22	8.12	54.1	108.3	162.4	216.6	270.7
21	.89	.79	.68	.57	.47	.36	.25	.15	8.04	3.6	7.2	60.8	4.4	68.0
22	.88	.77	.65	.54	.42	.31	.19	.07	7.96	3.1	6.1	59.2	2.2	5.3
23	.88	.75	.63	.50	.38	.25	.13	7.00	.88	2.5	5.0	7.6	10.1	62.6
24	.87	.73	.60	.47	.33	.20	.06	6.93	.80	2.0	4.0	5.9	07.9	59.9
88 25	0.86	1.71	2.57	3.43	4.29	5.14	6.00	6.86	7.72	51.4	102.9	154.3	205.7	257.2
26	.85	.70	.55	.39	.24	.09	5.94	.79	.63	0.9	1.8	2.7	3.6	4.5
27	.84	.68	.52	.36	.20	5.04	.88	.71	.55	50.4	100.7	51.1	201.4	51.8
28	.83	.66	.49	.32	.15	4.98	.81	.64	.47	49.8	99.6	49.4	199.3	49.1
29	.82	.64	.46	.29	.11	.93	.75	.57	.39	9.3	8.5	7.8	7.1	6.4
88 30	0.81	1.62	2.44	3.25	4.06	4.87	5.69	6.50	7.31	48.7	97.5	146.2	194.9	243.7
31	.80	.61	.41	.21	4.02	.82	.62	.42	.23	8.2	6.4	4.6	2.8	40.9
32	.79	.59	.38	.18	3.97	.76	.56	.35	.15	7.6	5.3	2.9	90.6	38.2
33	.78	.57	.36	.14	.93	.71	.50	.28	7.07	7.1	4.2	41.3	88.4	5.5
34	.78	.55	.33	.10	.88	.66	.43	.21	6.98	6.6	3.1	39.7	6.3	2.8
88 35	0.77	1.53	2.30	3.07	3.84	4.60	5.37	6.14	6.90	46.0	92.0	138.1	184.1	230.1
36	.76	.52	.27	.03	.79	.55	.31	.06	.82	5.5	91.0	6.4	81.9	27.4
37	.75	.50	.25	3.00	.75	.49	.24	5.99	.74	4.9	89.9	4.8	79.8	4.7
38	.74	.48	.22	2.96	.70	.44	.18	.92	.66	4.4	8.8	3.2	7.6	22.0
39	.73	.46	.19	.92	.65	.39	.12	.85	.58	3.9	7.7	1.6	5.4	19.3
88 40	0.72	1.44	2.17	2.89	3.61	4.33	5.05	5.78	6.50	43.3	86.6	130.0	173.3	210.6
41	.71	.43	.14	.85	.57	.28	4.99	.70	.42	2.8	5.6	28.3	71.1	3.9
42	.70	.41	.11	.82	.52	.22	.93	.63	.34	2.2	4.5	6.7	68.9	11.2
43	.69	.39	.09	.78	.48	.17	.86	.56	.26	1.7	3.4	5.1	6.8	08.5
44	.69	.37	.06	.74	.43	.12	.80	.49	.17	1.2	2.3	3.5	4.6	5.8
88 45	0.68	1.35	2.03	2.71	3.39	4.06	4.74	5.42	6.09	40.6	81.2	121.8	162.4	203.1
46	.67	.34	2.00	.67	.34	4.01	.67	.34	6.01	40.1	80.1	20.2	60.3	200.3
47	.66	.32	1.98	.63	.29	3.95	.61	.27	5.93	39.5	79.1	18.6	58.1	197.6
48	.65	.30	.95	.60	.25	.90	.55	.20	.85	9.0	8.0	7.0	5.9	4.9
49	.64	.28	.92	.56	.20	.84	.48	.13	.77	8.4	6.9	5.3	3.8	92.2
88 50	0.63	1.26	1.90	2.53	3.16	3.79	4.42	5.05	5.69	37.9	75.8	113.7	151.6	189.5
51	.62	.25	.87	.49	.11	.74	.36	4.98	.60	7.4	4.7	2.1	49.4	6.8
52	.61	.23	.84	.45	.07	.68	.30	.91	.53	6.8	3.6	10.5	7.3	4.1
53	.60	.21	.81	.42	3.02	.63	.23	.84	.44	6.3	2.6	08.8	5.1	81.4
54	.60	.19	.79	.38	2.98	.57	.17	.77	.36	5.7	1.5	7.2	3.0	78.7
88 55	0.59	1.17	1.76	2.35	2.93	3.52	4.11	4.69	5.28	35.2	70.4	105.6	140.8	176.0
56	.58	.16	.73	.31	.89	.47	4.04	.62	.20	4.7	69.3	4.0	38.6	3.3
57	.57	.14	.71	.27	.84	.41	3.98	.55	.12	4.1	8.2	2.3	6.5	70.6
58	.56	.12	.68	.24	.80	.36	.92	.48	5.04	3.6	7.1	100.7	4.3	67.9
59	.55	.10	.65	.20	.75	.30	.85	.41	4.96	3.0	6.1	99.1	2.1	5.2
88 60	0.54	1.08	1.62	2.17	2.71	3.25	3.79	4.33	4.87	32.5	65.0	97.5	130.0	162.5

Lat.	Latitude 88° to 89°—Meridional arcs.						Latitude 88°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
88 00	31.027			1861.63					
1	7	1	31.03	.63	1	1 861.6	0 1	65.0	0.0
2	7	2	62.05	.63	2	3 723.3	2	130.0	0.0
3	7	3	93.08	.63	3	5 584.9	3	194.9	0.1
4	7	4	124.11	.63	4	7 446.5	4	259.9	0.2
88 05	31.027	5	155.14	1861.63	5	9 308.2	0 5	324.9	0.2
6	7	6	186.16	.63	6	11 169.8	6	389.8	0.3
7	7	7	217.19	.64	7	13 031.4	7	454.8	0.5
8	7	8	248.22	.64	8	14 893.1	8	519.8	0.6
9	7	9	279.24	.64	9	16 754.7	9	584.7	0.8
88 10	31.027	10	310.27	1861.64	10	18 616.4	0 10	649.7	0.9
11	7	1	341.30	.64	1	20 478.0	15	974.6	2.1
12	7	2	372.33	.64	2	22 339.6	20	1 299.4	3.8
13	7	3	403.35	.64	3	24 201.3	25	1 624.3	5.9
14	7	4	434.38	.64	4	26 062.9	30	1 949.1	8.5
88 15	31.027	15	465.41	1861.64	15	27 924.5	0 35	2 273.9	11.6
16	7	6	496.44	.64	6	29 786.2	40	2 598.8	15.1
17	7	7	527.46	.64	7	31 647.8	45	2 923.6	19.1
18	7	8	558.49	.64	8	33 509.5	50	3 248.4	23.6
19	7	9	589.52	.64	9	35 371.1	55	3 573.2	28.6
88 20	31.027	20	620.55	1861.64	20	37 232.7	1 00	3 898.1	34.0
21	7	1	651.57	.64	1	39 094.4	05	4 222.9	39.9
22	7	2	682.60	.64	2	40 956.0	10	4 547.6	46.3
23	7	3	713.63	.64	3	42 817.7	15	4 872.4	53.1
24	7	4	744.65	.64	4	44 679.3	20	5 197.2	60.4
88 25	31.027	25	775.68	1861.64	25	46 540.9	1 25	5 521.9	68.2
26	7	6	806.71	.64	6	48 402.6	30	5 846.7	76.5
27	7	7	837.74	.64	7	50 264.2	35	6 171.4	85.2
28	7	8	868.76	.64	8	52 125.9	40	6 496.1	94.4
29	7	9	899.79	.64	9	53 987.5	45	6 820.8	104.1
88 30	31.027	30	930.82	1861.64	30	55 849.1	1 50	7 145.5	114.3
31	7	1	961.85	.64	1	57 910.8	55	7 470.2	124.9
32	7	2	992.87	.64	2	59 572.4	2 00	7 795	136
33	7	3	1 023.90	.64	3	61 434.1	3 00	11 689	306
34	7	4	1 054.93	.64	4	63 295.7	4 00	15 580	544
88 35	31.027	35	1 085.95	1861.64	35	65 157.4	5 00	19 466	849
36	7	6	1 116.98	.64	6	67 019.0	6 00	23 347	1 223
37	7	7	1 148.01	.64	7	68 880.7	7 00	27 220	1 664
38	7	8	1 179.04	.64	8	70 742.3	8 00	31 085	2 172
39	7	9	1 210.06	.65	9	72 603.9	9 00	34 940	2 748
88 40	31.027	40	1 241.09	1861.65	40	74 465.6	10 00	38 785	3 391
41	7	1	1 272.12	.65	1	76 327.2	11 00	42 618	4 101
42	7	2	1 303.15	.65	2	78 188.9	12 00	46 438	4 878
43	7	3	1 334.17	.65	3	80 050.5	13 00	50 244	5 721
44	7	4	1 365.20	.65	4	81 912.2	14 00	54 035	6 631
88 45	31.027	45	1 396.23	1861.65	45	83 773.8	15 00	57 809	7 606
46	7	6	1 427.26	.65	6	85 635.5	16 00	61 565	8 647
47	7	7	1 458.28	.65	7	87 497.1	17 00	65 303	9 754
48	7	8	1 489.31	.65	8	89 358.8	18 00	69 021	10 925
49	7	9	1 520.34	.65	9	91 220.4	19 00	72 718	12 161
88 50	31.027	50	1 551.37	1861.65	50	93 082.1	20 00	76 393	13 462
51	7	1	1 582.39	.65	1	94 943.7	21 00	80 045	14 826
52	7	2	1 613.42	.65	2	96 805.4	22 00	83 672	16 254
53	7	3	1 644.45	.65	3	98 667.0	23 00	87 274	17 745
54	7	4	1 675.48	.65	4	100 528.7	24 00	90 849	19 298
88 55	31.027	55	1 706.50	1861.65	55	102 390.3	25 00	94 397	20 914
56	7	6	1 737.53	.65	6	104 252.0	26 00	97 915	22 591
57	7	7	1 768.56	.65	7	106 113.6	27 00	101 405	24 330
58	7	8	1 799.59	.65	8	107 975.3	28 00	104 863	26 129
59	7	9	1 830.61	.65	9	109 836.9	29 00	108 289	27 988
88 60	31.027	60	1 861.64	1861.65	60	111 698.6	30 00	111 683	29 906

Latitude 89° to 90°—Arcs of the parallel in meters.

Lat.	1″	2″	3″	4″	5″	6″	7″	8″	9″	1′	2′	3′	4′	5′
° ′														
89 00	0.54	1.08	1.62	2.17	2.71	3.25	3.79	4.33	4.87	32.5	65.0	97.5	130.0	162.4
1	.53	.06	.60	.13	.66	.19	.73	.26	.79	1.9	3.9	5.8	27.8	59.7
2	.52	.05	.57	.09	.62	.14	.66	.19	.71	1.4	2.8	4.2	5.6	7.0
3	.51	.03	.54	.06	.57	.09	.60	.11	.63	0.9	1.7	2.6	3.5	4.3
4	.51	1.01	.52	2.02	.53	3.03	.54	4.04	.55	30.3	60.6	91.0	21.3	51.6
89 05	0.50	0.99	1.49	1.99	2.48	2.98	3.47	3.97	4.47	29.8	59.6	89.3	119.1	148.9
6	.49	.97	.46	.95	.44	.92	.41	.90	.39	9.2	8.5	7.7	7.0	6.2
7	.48	.96	.43	.91	.39	.87	.35	.83	.30	8.7	7.4	6.1	4.8	3.5
8	.47	.94	.41	.88	.35	.82	.29	.75	.22	8.2	6.3	4.5	2.6	40.8
9	.46	.92	.38	.84	.30	.76	.22	.68	.14	7.6	5.2	2.9	10.5	38.1
89 10	0.45	0.90	1.35	1.81	2.26	2.71	3.16	3.61	4.06	27.1	54.2	81.2	108.3	135.4
11	.44	.88	.33	.77	.21	.65	.10	.54	3.98	6.5	3.1	79.6	6.1	2.7
12	.43	.87	.30	.73	.17	.60	3.03	.47	.90	6.0	2.0	8.0	4.0	30.0
13	.42	.85	.27	.70	.12	.55	2.97	.39	.82	5.5	50.9	6.4	101.8	27.3
14	.41	.83	.24	.66	.08	.49	.91	.32	.74	4.9	49.8	4.7	99.6	4.5
89 15	0.41	0.81	1.22	1.62	2.03	2.44	2.84	3.25	3.65	24.4	48.7	73.1	97.5	121.8
16	.40	.79	.19	.59	1.99	.38	.78	.18	.57	3.8	7.7	71.5	5.3	19.1
17	.39	.78	.16	.55	.94	.33	.72	.10	.49	3.3	6.6	69.9	3.1	6.4
18	.38	.76	.14	.52	.90	.27	.65	3.03	.41	2.7	5.5	8.2	91.0	3.7
19	.37	.74	.11	.48	.85	.22	.59	2.96	.33	2.2	4.4	6.6	88.8	11.0
89 20	0.36	0.72	1.08	1.44	1.81	2.17	2.53	2.89	3.25	21.7	43.3	65.0	86.6	108.3
21	.35	.70	.06	.41	.76	.12	.46	.82	.17	1.1	2.2	3.4	4.5	5.6
22	.34	.69	.03	.37	.72	.06	.40	.74	.09	0.6	1.2	1.7	2.3	2.9
23	.33	.67	1.00	.34	.67	2.00	.34	.67	3.01	20.0	40.1	60.1	80.1	100.2
24	.32	.65	0.97	.30	.63	1.95	.28	.60	2.93	19.5	39.0	58.5	78.0	97.5
89 25	0.32	0.63	0.95	1.26	1.58	1.90	2.21	2.53	2.84	19.0	37.9	56.9	75.8	94.8
26	.31	.61	.92	.23	.53	.84	.15	.46	.76	8.4	6.8	5.2	3.6	92.1
27	.30	.60	.89	.19	.49	.79	.09	.38	.68	7.9	5.7	3.6	71.5	89.4
28	.29	.58	.87	.15	.44	.73	2.02	.31	.60	7.3	4.7	2.0	69.3	6.6
29	.28	.56	.84	.12	.40	.68	1.96	.24	.52	6.8	3.6	50.4	7.1	3.9
89 30	0.27	0.54	0.81	1.08	1.35	1.62	1.89	2.17	2.44	16.2	32.5	48.7	65.0	81.2
31	.26	.52	.78	.05	.31	.57	.83	.09	.36	5.7	1.4	7.1	2.8	78.5
32	.25	.50	.76	1.01	.26	.52	.77	2.02	.27	5.2	30.3	5.5	60.7	5.8
33	.24	.49	.73	0.97	.22	.46	.71	1.95	.19	4.6	29.2	3.9	58.5	3.1
34	.23	.47	.70	.94	.17	.41	.64	.88	.11	4.1	8.2	2.2	6.3	70.4
89 35	0.23	0.45	0.68	0.90	1.13	1.35	1.58	1.81	2.03	13.5	27.1	40.6	54.2	67.7
36	.22	.43	.65	.87	.08	.30	.52	.73	1.95	3.0	6.0	39.0	52.0	5.0
37	.21	.41	.62	.83	1.04	.25	.45	.66	.87	2.5	4.9	7.4	49.8	62.3
38	.20	.40	.60	.79	0.99	.19	.39	.59	.79	1.9	3.8	5.7	7.7	59.6
39	.19	.38	.57	.76	.95	.14	.33	.52	.71	1.4	2.7	4.1	5.5	6.9
89 40	0.18	0.36	0.54	0.72	0.90	1.08	1.26	1.45	1.63	10.8	21.7	32.5	43.3	54.2
41	.17	.34	.51	.69	.86	1.03	.20	.37	.54	10.3	20.6	30.9	41.2	51.4
42	.16	.32	.49	.65	.81	0.97	.14	.30	.46	9.7	19.5	29.2	39.0	48.7
43	.15	.31	.46	.61	.77	.92	.07	.23	.38	9.2	8.4	7.6	6.8	6.0
44	.14	.29	.43	.58	.72	.87	1.01	.15	.30	8.7	7.3	6.0	4.7	3.3
89 45	0.14	0.27	0.41	0.54	0.68	0.81	0.95	1.08	1.22	8.1	16.2	24.4	32.5	40.6
46	.13	.25	.38	.51	.63	.76	.88	1.01	.14	7.6	5.2	2.7	30.3	37.9
47	.12	.23	.35	.47	.59	.70	.82	0.94	1.06	7.0	4.1	21.1	28.2	5.2
48	.11	.22	.32	.43	.54	.65	.76	.87	0.98	6.5	3.0	19.5	6.0	32.5
49	.10	.20	.30	.40	.50	.60	.70	.79	.89	6.0	1.9	7.9	3.8	29.8
89 50	0.09	0.18	0.27	0.36	0.45	0.54	0.63	0.72	0.81	5.4	10.8	16.2	21.7	27.1
51	.08	.16	.24	.33	.41	.49	.57	.65	.73	4.9	9.7	4.6	19.5	4.4
52	.07	.14	.22	.29	.36	.43	.51	.58	.65	4.3	8.7	3.0	7.3	21.7
53	.06	.13	.19	.25	.32	.38	.44	.51	.57	3.8	7.6	11.4	5.2	19.0
54	.05	.11	.16	.22	.27	.32	.38	.43	.49	3.2	6.5	9.7	3.0	6.2
89 55	0.05	0.09	0.14	0.18	0.23	0.27	0.31	0.36	0.41	2.7	5.4	8.1	10.8	13.5
56	.04	.07	.11	.14	.18	.22	.25	.29	.32	2.2	4.3	6.5	8.7	10.8
57	.03	.05	.08	.11	.14	.16	.19	.22	.24	1.6	3.2	4.9	6.5	8.1
58	.02	.04	.05	.07	.09	.11	.13	.14	.16	1.1	2.2	3.2	4.3	5.4
59	.01	.02	.03	.04	.05	.05	.06	.07	.08	0.5	1.1	1.6	2.2	2.7
89 60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0

Lat.	Latitude 89° to 90°—Meridional arcs.						Latitude 89°—Co-ordinates of curvature.		
	Value of 1″	Sums of seconds for middle latitude.		Value of 1′	Sums of minutes for middle latitude.		Longitude.	X	Y
° ′	*Meters.*	″	*Meters.*	*Meters.*	′	*Meters.*	° ′	*Meters.*	*Meters.*
89 00	31.027			1861.65					
1	8	1	31.03	.65	1	1 861.7	0 1	32.5	0.0
2	8	2	62.05	.65	2	3 723.3	2	65.0	0.0
3	8	3	93.08	.65	3	5 585.0	3	97.5	0.0
4	8	4	124.11	.65	4	7 446.6	4	130.0	0.1
89 05	31.028	5	155.14	1861.65	5	9 308.3	0 5	162.4	0.1
6	8	6	186.16	.65	6	11 169.9	6	194.9	0.2
7	8	7	217.19	.65	7	13 031.6	7	227.4	0.2
8	8	8	248.22	.65	8	14 893.2	8	259.9	0.3
9	8	9	279.25	.65	9	16 754.9	9	292.4	0.4
89 10	31.028	10	310.28	1861.65	10	18 616.5	0 10	324.9	0.5
11	8	1	341.30	.65	1	20 478.2	15	487.3	1.1
12	8	2	372.33	.65	2	22 339.8	20	649.8	1.9
13	8	3	403.36	.65	3	24 201.5	25	812.2	3.0
14	8	4	434.39	.65	4	26 063.1	30	974.7	4.3
89 15	31.028	15	465.41	1861.65	15	27 924.8	0 35	1 137.1	5.8
16	8	6	496.44	.65	6	29 786.4	40	1 299.6	7.6
17	8	7	527.47	.65	7	31 648.1	45	1 462.0	9.6
18	8	8	558.49	.65	8	33 509.7	50	1 624.5	11.8
19	8	9	589.52	.65	9	35 371.4	55	1 786.9	14.3
89 20	31.028	20	620.55	1861.65	20	37 233.0	1 00	1 949.3	17.0
21	8	1	651.58	.65	1	39 094.7	05	2 111.7	20.0
22	8	2	682.60	.65	2	40 956.3	10	2 274.2	23.2
23	8	3	713.63	.65	3	42 818.0	15	2 436.6	26.6
24	8	4	744.66	.65	4	44 679.6	20	2 599.0	30.2
89 25	31.028	25	775.69	1861.65	25	46 541.3	1 25	2 761.4	34.1
26	8	6	806.71	.65	6	48 403.0	30	2 923.8	38.3
27	8	7	837.74	.65	7	50 264.6	35	3 086.2	42.6
28	8	8	868.77	.65	8	52 126.3	40	3 248.6	47.3
29	8	9	899.80	.65	9	53 987.9	45	3 411.0	52.1
89 30	31.028	30	930.83	1861.65	30	55 849.6	1 50	3 573.3	57.2
31	8	1	961.85	.65	1	57 711.2	55	3 735.7	62.5
32	8	2	992.88	.65	2	59 572.9	2 00	3 898	68
33	8	3	1 023.91	.65	3	61 434.5	3 00	5 846	153
34	8	4	1 054.94	.65	4	63 296.2	4 00	7 791	272
89 35	31.028	35	1 085.96	1861.65	35	65 157.8	5 00	9 735	425
36	8	6	1 116.99	.65	6	67 019.5	6 00	11 675	612
37	8	7	1 148.02	.65	7	68 881.2	7 00	13 612	832
38	8	8	1 179.05	.65	8	70 742.8	8 00	15 545	1 087
39	8	9	1 210.07	.65	9	72 604.5	9 00	17 473	1 375
89 40	31.028	40	1 241.10	1861.66	40	74 466.1	10 00	19 395	1 697
41	8	1	1 272.13	.66	1	76 327.8	11 00	21 312	2 052
42	8	2	1 303.16	.66	2	78 189.4	12 00	23 222	2 440
43	8	3	1 334.18	.66	3	80 051.1	13 00	25 126	2 862
44	8	4	1 365.21	.66	4	81 912.7	14 00	27 021	3 317
89 45	31.028	45	1 396.24	1861.66	45	83 774.4	15 00	28 908	3 805
46	8	6	1 427.27	.66	6	85 636.1	16 00	30 787	4 326
47	8	7	1 458.29	.66	7	87 497.7	17 00	32 656	4 880
48	8	8	1 489.32	.66	8	89 359.4	18 00	34 515	5 466
49	8	9	1 520.35	.66	9	91 221.0	19 00	36 364	6 084
89 50	31.028	50	1 551.38	1861.66	50	93 082.7	20 00	38 202	6 735
51	8	1	1 582.40	.66	1	94 944.3	21 00	40 028	7 417
52	8	2	1 613.43	.66	2	96 806.0	22 00	41 841	8 132
53	8	3	1 644.46	.66	3	98 667.7	23 00	43 643	8 878
54	8	4	1 675.48	.66	4	100 529.3	24 00	45 430	9 655
89 55	31.028	55	1 706.51	1861.66	55	102 391.0	25 00	47 204	10 463
56	8	6	1 737.54	.66	6	104 252.6	26 00	48 964	11 302
57	8	7	1 768.57	.66	7	106 114.3	27 00	50 708	12 172
58	8	8	1 799.60	.66	8	107 975.9	28 00	52 438	13 072
59	8	9	1 830.62	.66	9	109 837.6	29 00	54 151	14 002
89 60	31.028	60	1 861.65	1861.66	60	111 699.3	30 00	55 848	14 962

Appendix No. 7.

FORMULÆ AND FACTORS FOR THE COMPUTATION OF GEODETIC LATITUDES, LONGITUDES, AND AZIMUTHS.

[Third edition.*]

When the geographical co-ordinates of latitude and longitude of a point on the earth's surface, and the distance and azimuth to another point are known, we may treat the problem of computing the latitude and longitude of the second point and the reverse azimuth in two different ways.

We may either solve the spheroidal triangle formed by the two points and the pole as a whole, arriving at trigonometrical functions of the sought co-latitude, azimuth and difference of longitude; or we may seek expressions for the differences of the sought from the given data.

The former or direct method has the inconvenience of requiring the use of ten places of decimals in the computation, in order to give the positions with a degree of exactness corresponding to that of the known distance between the two points, while the second leads to very convenient expressions, on account of the smallness of the differential arcs in most cases of triangulation.

When, however, the arc between the two points reaches several degrees in length, the direct method must be resorted to. This solution has been very completely and elegantly performed by BESSEL, and is given in *Astronom. Nachrichten*, No. 86, 1826.

Adopting the second method, we follow in the main PUISSANT (*Traité de Géodésie*),† in the development of the difference of latitude of two points on the spheroid in terms of the distance, azimuth and latitude of the given point. It will be convenient first to recall the expressions of several lines of an ellipse in terms involving the latitude, L, which is the angle that the normal to any point on the ellipse makes with the major axis.

Designating the major or equatorial semi-axis by a, and the minor or polar semi-axis by b, then the *ellipticity* or ratio of their difference to the former is

$$\varepsilon = \frac{a-b}{a}$$

The eccentricity e is expressed by

$$e^2 = \frac{a^2 - b^2}{a^2}$$

being shown in the figure by cf, the distance from the center to the focus.

The normal

$$nl = \frac{a(1-e^2)}{(1-e^2\sin^2 L)^{\frac{1}{2}}}$$

The normal nm produced to the minor axis

$$N = \frac{a}{(1-e^2\sin^2 L)^{\frac{1}{2}}}$$

The abscissa

$$cd = no = N\cos L$$

this is the radius of a parallel on the spheroid.

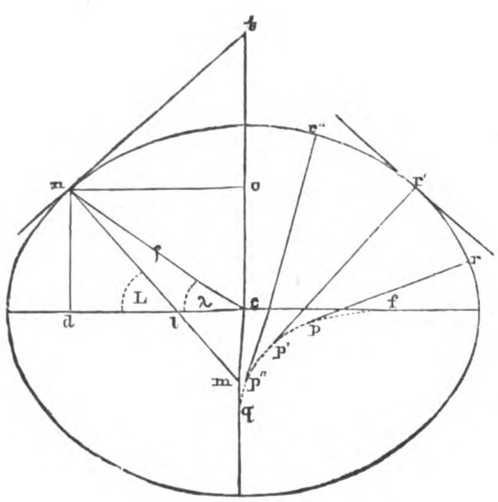


FIG. 1.

*These formulæ and tables of log. factors were first printed in United States Coast Survey Report for 1860, Appendix No. 36; the second edition followed in United States Coast Survey Report for 1875, Appendix No. 19.

†Traité de Géodésie. Par L. Puissant. Third edition. Tome I, Chp. XV, p. 347 and fol. Paris, 1842.

The tangent nt ending at the minor axis $=$ N cot L
The ordinate

$$nd = \frac{a\,(1-e^2)\sin \mathrm{L}}{(1-e^2\sin^2 \mathrm{L})^{\frac{1}{2}}}$$

The reduced or geocentric latitude being λ, we have

$$\tan\lambda = \frac{b^2}{a^2}\tan \mathrm{L}$$

The radius vector

$\rho = a\,(1-e^2\sin^2\lambda)^{\frac{1}{2}}$, neglecting terms in e^4 and higher terms.

The radius of curvature, $r\,p$, $r'\,p'$, $r''\,p''$, at any point on the ellipse, is

$$\mathrm{R} = \frac{a\,(1-e^2)}{(1-e^2\sin^2 \mathrm{L})^{\frac{3}{2}}}$$

The terminal points, f, p, p', p'', q, form an evolute; at the equator, where sin L $= 0$, $\mathrm{R} = \dfrac{b^2}{a}$, and the center of curvature is in the focus; at the pole, where sin L $= 1$, $\mathrm{R} = \dfrac{a^2}{b}$

The radius of curvature, R, and the normal, N, are the principal functions used in geodesy. It will be observed that radii of curvature for different latitudes do not intersect unless produced, and that when they lie in different meridian planes on the spheroid they will not intersect at all.

A, B, in Fig. 2, are two points on a spheroid of revolution, having the latitudes L, L′, and joined by the geodetic line $AB = s$, making the angles with the meridian, $PAB = 180 - Z$, $PBA = Z' - 180°$. The azimuths, Z, are reckoned from south around by west in consequence of the latitudes being reckoned from the equator toward the poles, by settled custom, without which the meridional co-ordinate of a point would be more properly measured from the pole, and the azimuth of a line reckoned from the north. The angle APB, between the two meridional planes passing through A and B, is the difference of their longitudes, M, M′, which being reckoned positive to the westward, we have $\mathrm{M}' - \mathrm{M} = d\mathrm{M}$. Furthermore, An, Bn', Ar, Br', indicate the normals, N, N′, and the radii of curvature in the meridian, R, R′, at the points A and B.

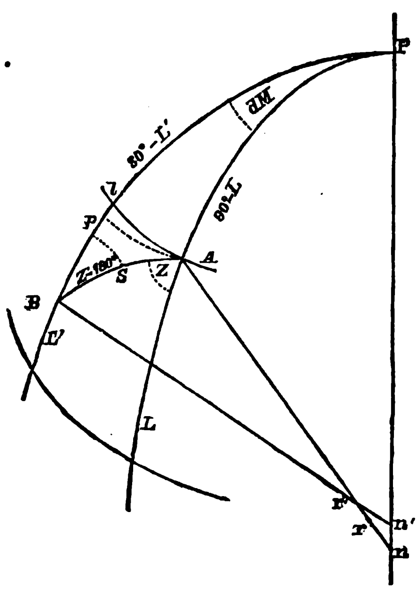


FIG. 2.

This being premised, and the latitude L of the point A being given, as well as the length K of the geodetic line AB, and its azimuth Z, we propose to find the latitude L′ of the point B, the angle dM, and the reverse azimuth Z′, by solving the geodetic triangle ABP. Writing λ, λ', for the co-latitudes, ξ for $180° - \mathrm{Z}$, and s for the arc AB, referred to radius $= 1$, we have, in a spherical triangle, for λ' the following equation:

$$\cos\lambda' = \cos\lambda\cos s + \sin\lambda\sin s\cos\xi$$

Observing now that s is always a small arc, rarely exceeding 1°, and generally less than 30′, we can develop the increment of λ with reference to that of s in a rapidly converging series, and will have, by Taylor's theorem

$$\lambda' = \lambda + \frac{d\lambda}{ds}s + \frac{1}{2}\cdot\frac{d^2\lambda}{ds^2}s^2 + \frac{1}{6}\cdot\frac{d^3\lambda}{ds^3}s^3 + \ldots \quad (a)$$

In order to determine the differential coefficients, we consider a differential spherical triangle having the sides λ, ds, and $\lambda + d\lambda$, in which

$$\cos(\lambda + d\lambda) = \cos\lambda\cos ds + \sin\lambda\sin ds\cos\xi$$

and, developing by the known processes of the differential calculus, we find

$$\frac{d\lambda}{ds} = -\cos\xi \qquad \frac{d^2\lambda}{ds^2} = +\sin^2\xi\cot\lambda \qquad \frac{d^3\lambda}{ds^3} = +\sin^2\xi\cos\xi\,(1+3\cot^2\lambda)$$

Introducing these values in (a), we obtain

$$\lambda' - \lambda = -s\cos\xi + \frac{1}{2}s^2\sin^2\xi\cot\lambda + \frac{1}{6}s^3\sin^2\xi\cos\xi\,(1+3\cot^2\lambda) + \ldots$$

and substituting L, L′, and Z in this expression we have for the difference of latitude

$$\mathrm{L} - \mathrm{L}' = s\cos \mathrm{Z} + \frac{1}{2}s^2\sin^2 \mathrm{Z}\tan \mathrm{L} - \frac{1}{6}s^3\sin^2 \mathrm{Z}\cos \mathrm{Z}\,(1+3\tan^2 \mathrm{L}) + \ldots \qquad (b)$$

It will be readily seen that the first term expresses the distance on the meridian $P\,B$ from B to p, the foot of the perpendicular from A; the second term, the distance very nearly from p to the parallel passing through A; while the third term is a further approximation, and so on.

Referring now our case to a sphere, having the radius equal N, or its center at the point where the normal $A\,n$ intersects the polar diameter of the spheroid, we have

$$s = \frac{\mathrm{K}}{\mathrm{N}}$$

substituting which we have

$$\mathrm{L} - \mathrm{L}' = \frac{\mathrm{K}\cos \mathrm{Z}}{\mathrm{N}} + \frac{1}{2}\cdot\frac{\mathrm{K}^2\sin^2 \mathrm{Z}\tan \mathrm{L}}{\mathrm{N}^2} - \frac{1}{6}\cdot\frac{\mathrm{K}^3\sin^2 \mathrm{Z}\cos \mathrm{Z}}{\mathrm{N}^3}(1+3\tan^2 \mathrm{L}) + \ldots \qquad (c)$$

This difference of latitude is, however, referred to a sphere whose radius is N, and requires still to be transformed by referring it to one whose radius is the radius of curvature in the meridian for the middle latitude, $\mathrm{R_m}$. Since we do not at first know the middle latitude, it is more convenient to refer to the radius of curvature R of the starting-point, the latitude of which is known, and then seek the small correction due to the ratio of R to $\mathrm{R_m}$.

Multiplying, then, equation (c) by $\frac{\mathrm{N}}{\mathrm{R}}$, and dividing, moreover, by arc 1″, in order to express $d\,\mathrm{L}$ in seconds of arc, we get

$$-d\,\mathrm{L} = \frac{\mathrm{K}}{\mathrm{R}\,\mathrm{arc}\,1''}\cos \mathrm{Z} + \frac{1}{2}\cdot\frac{\mathrm{K}^2}{\mathrm{R\,N}\,\mathrm{arc}\,1''}\sin^2 \mathrm{Z}\tan \mathrm{L} - \frac{1}{6}\cdot\frac{\mathrm{K}^3}{\mathrm{R\,N}^2\,\mathrm{arc}\,1''}\sin^2 \mathrm{Z}\cos \mathrm{Z}\,(1+3\tan^2 \mathrm{L}) + \ldots \qquad (d)$$

The computation of this series is facilitated by tables giving the logarithms of the following factors to the argument of L, viz:

$$\mathrm{B} = \frac{1}{\mathrm{R}\,\mathrm{arc}\,1''} \qquad \mathrm{C} = \frac{\tan \mathrm{L}}{2\,\mathrm{R\,N}\,\mathrm{arc}\,1''}$$

moreover, substituting the in third term the value of the first term, designated by h, we can write it

$$\frac{1}{6}\cdot h\,\frac{\mathrm{K}^2\sin^2 \mathrm{Z}}{\mathrm{N}^2}(1+3\tan^2 \mathrm{L})$$

and tabulate another factor

$$\mathrm{E} = \frac{1+3\tan^2 \mathrm{L}}{6\,\mathrm{N}^2}$$

when our formula for computation becomes

$$-\delta\,\mathrm{L} = \mathrm{K}\cos \mathrm{Z}\,.\,\mathrm{B} + \mathrm{K}^2\sin^2 \mathrm{Z}\,.\,\mathrm{C} - h\,\mathrm{K}^2\sin^2 \mathrm{Z}\,.\,\mathrm{E} + \ldots\ldots \qquad (e)$$

In order, finally, to obtain the true $d\,\mathrm{L}$ referred to $\mathrm{R_m}$, we must increase $\delta\,\mathrm{L}$ by $\frac{\mathrm{R}-\mathrm{R_m}}{\mathrm{R_m}}\delta\,\mathrm{L}$ Now

$$\mathrm{R}-\mathrm{R_m}=a\,(1-e^2)\left(\frac{1}{(1-e^2\sin^2\mathrm{L})^{\frac{3}{2}}}-\frac{1}{(1-e^2\sin^2\mathrm{L_m})^{\frac{3}{2}}}\right)$$

$$=a\,(1-e^2)\frac{\frac{3}{2}e^2\,(\sin^2\mathrm{L}-\sin^2\mathrm{L_m})}{(1-e^2\sin^2\mathrm{L})^{\frac{3}{2}}\,(1-e^2\sin^2\mathrm{L_m})^{\frac{3}{2}}}$$

by developing and neglecting terms involving higher powers of e^2; but

$$\sin^2\mathrm{L}-\sin^2\mathrm{L_m}=\sin\,(\mathrm{L}-\mathrm{L_m})\,\sin\,(\mathrm{L}+\mathrm{L_m})=\delta\,\mathrm{L}\sin 1''\,\sin\mathrm{L}\cos\mathrm{L}\text{ very nearly,}$$

because

$$\tfrac{1}{2}\sin 2\,\mathrm{L}=\sin\mathrm{L}\cos\mathrm{L}$$

hence we write

$$\frac{\mathrm{R}-\mathrm{R_m}}{\mathrm{R_m}}=\frac{a\,(1-e^2)\,\frac{3}{2}\,e^2\,\delta\,\mathrm{L}\sin 1''\,\sin\mathrm{L}\cos\mathrm{L}}{(1-e^2\sin^2\mathrm{L})^{\frac{3}{2}}\,(1-e^2\sin^2\mathrm{L_m})^{\frac{3}{2}}}\times\frac{(1-e^2\sin^2\mathrm{L_m})^{\frac{3}{2}}}{a\,(1-e^2)}=\frac{\frac{3}{2}\,e^2\,\delta\,\mathrm{L}\sin 1''\,\sin\mathrm{L}\cos\mathrm{L}}{(1-e^2\sin^2\mathrm{L})^{\frac{3}{2}}}$$

making

$$\mathrm{D}=\frac{\frac{3}{2}\,e^2\sin\mathrm{L}\cos\mathrm{L}\sin 1''}{(1-e^2\sin^2\mathrm{L})^{\frac{3}{2}}}$$

we get, for the desired corrective term

$$\frac{\mathrm{R}-\mathrm{R_m}}{\mathrm{R_m}}\delta\,\mathrm{L}=(\delta\,\mathrm{L})^2\,\mathrm{D}$$

and we finally have, for the true difference of latitude

$$-d\,\mathrm{L}=\mathrm{K}\cos\mathrm{Z}\,.\,\mathrm{B}+\mathrm{K}^2\sin^2\mathrm{Z}\,.\,\mathrm{C}+(\delta\,\mathrm{L})^2\,.\,\mathrm{D}-h\,\mathrm{K}^2\sin^2\mathrm{Z}\,.\,\mathrm{E}\qquad(1)$$

which formula, although of a somewhat complicated derivation, is very simple and convenient in practical computation with the aid of the tabulated factors, B, C, D, E. The term * $(\delta\,\mathrm{L})^2\,\mathrm{D}$ is here interposed between the second and third terms of the series proper, because the latter is frequently not required, being insensible when the distance K is less than about 10 miles, or log K in meters less than 4.23 The term $(\delta\,\mathrm{L})^2\,\mathrm{D}$ should be used whenever log h exceeds 2.31, and h^2 may be used for $(\delta\,\mathrm{L})^2$ in all cases where log K does not exceed 4.93

The term depending on the fourth differential co-officient, neglected in equation (a), never exceeds $0''.001$ for $s=1^\circ$, or $\mathrm{K}=100\,000$ meters, and may therefore be safely neglected in practice.

For secondary triangulation, and when the sides do not exceed about 12 miles, or 20 000 meters, the formula (1) may be advantageously reduced to the following:

$$-d\,\mathrm{L}=\mathrm{K}\cos\mathrm{Z}\,.\,\mathrm{B}+\mathrm{K}^2\sin^2\mathrm{Z}\,.\,\mathrm{C}+h^2\,\mathrm{D}\qquad(2)$$

In order next to deduce the angle $A\,P\,B$ between the meridional planes passing through A and B and intersecting in the polar axis, or the difference $d\,\mathrm{M}$ of the longitudes M and M′ of the points A and B, counted from east to west, we avail ourselves of the latitude L′ of B, which has become known by the previous calculation, and have simply, using the same notation as before

$$\sin\lambda:\sin\xi=\sin s:\sin d\,\mathrm{M}$$

Referring s to a sphere the radius of which is the normal $\mathrm{B}\,n'=\mathrm{N}'$, we have $s=\frac{\mathrm{K}}{\mathrm{N}'}$ and assuming for the present the small arcs s and d M proportional to their sines, we obtain

$$d\,\mathrm{M}=\frac{\mathrm{K}\sin\mathrm{Z}}{\mathrm{N}'\cos\mathrm{L}'\,\mathrm{arc}\,1''}$$

* This term was devised by the writer of this article in 1846, while arranging the formulæ for use in the Coast Survey, and putting them into the form above given, in which they have been employed ever since.—J. E. H.

dividing by arc 1″ in order to obtain d M, expressed in seconds of arc. The table gives the logarithm of the factor $A = \frac{1}{N \text{ arc } 1''}$, which must be taken out for L′. We have: $d\,M = \frac{K \sin Z\, A'}{\cos L'}$

In order to correct for the assumption that the small arcs s and d M are proportional to their sines, we use a table giving the differences of the logarithms of the arcs and sines. This table is given on page 365; in using it, take out the differences for the arguments log K and log d M, the first with a negative, the second with a positive sign, and add their algebraic sum to log d M.

We obtain, finally, the reverse azimuth Z′ by considering that in the spherical triangle $A\,P\,B$ (fig. 2) we have the following relation:

$$\cot \tfrac{1}{2}\,(\xi+\xi') = \tan \tfrac{1}{2}\,d\,M \frac{\cos \frac{1}{2}\,(\lambda+\lambda')}{\cos \frac{1}{2}\,(\lambda'-\lambda)} = \tan\,\tfrac{1}{2}\,d\,M \frac{\sin \frac{1}{2}\,(L+L')}{\cos \frac{1}{2}\,(L'-L)}$$

but

$$\xi = 180^\circ - Z$$

therefore

$$\cot \tfrac{1}{2}\,(180^\circ - Z + \xi') = -\tan \tfrac{1}{2}\,(\xi' - Z)$$

or

$$-\tan \tfrac{1}{2}\,(d\,Z) = \tan \tfrac{1}{2}\,(d\,M) \frac{\sin \frac{1}{2}\,(L+L')}{\cos \frac{1}{2}\,(L'-L)}$$

Assuming the tangents of $\frac{1}{2}\,d\,Z$ and $\frac{1}{2}\,d$ M proportional to their arcs, and writing λ for the middle latitude, we have

$$-d\,Z = d\,M \frac{\sin \lambda}{\cos \frac{1}{2}\,d\,L} \tag{4}$$

and

$$Z' = Z + 180^\circ + d\,Z$$

When the difference of longitude is very large, it may be necessary to correct for the error in the assumption that $\tan \frac{1}{2}\,d\,Z : \tan \frac{1}{2}\,d\,M = d\,Z : d\,M$. By an obvious transformation, we find the correction to be $+\frac{1}{12}\,d\,M^3 \sin \lambda \cos^2 \lambda \sin^2 1''$, for which we write $+d\,M^3\,F$, where F is to be taken from a special table, given on page 374. This term is only 0″.01 when log d M=3.36 and need never be used for secondary triangulation. A convenient table for finding $\cos \frac{1}{2}\,d\,L$ is given on page 373.

In the first and second editions the tables were based upon the supposition that the earth is a spheroid of revolution, having its equatorial semi-diameter

$$a = 6\ 377\ 397.2 \text{ meters}$$

its polar semi-diameter

$$b = 6\ 356\ 079.0 \text{ meters}$$

and, consequently

$$a : b = 299.153 : 298.153$$

as derived by BESSEL, in *Astronom. Nachrichten*, Nos. 333 and 438, 1837 and December 1841, from the arcs measured up to that time. All geodetic computations made in the Coast Survey between 1844* and February, 1880, were based upon those elements. Very considerable additions have, however, been made to our knowledge of the figure and magnitude of the earth since Bessel's time. A late combination is that made by Col. A. R. Clarke, R. E., of the British Ordnance Survey, and published in "Comparisons of Standards of Length, made at the Ordnance Office, Southampton, 1866." He finds

$$a = 6\ 378\ 206.4 \text{ meters}$$
$$b = 6\ 356\ 583.8 \text{ meters}$$

consequently

$$a : b = 294.98 : 293.98$$

He also finds, by elaborate comparisons, that

$$1 \text{ meter} = 39.370432 \text{ inches}$$

which may well be taken as the most accurate value now known. This spheroid of 1866 was adopted in the survey by Superintendent Patterson in 1880.

In the present edition the tables of the log factors A, B, C, D, E, have been conformed to the Clarke spheroid.

The following examples will further illustrate the use of the formulæ and tables.

* Before 1844 a different spheroid of reference was employed by Superintendent Hassler.

L. M. Z.—FORM FOR PRIMARY TRIANGULATION.

		°	′	″
Z	Mount Blue to Mount Pleasant	26	19	28.69
∠	Ragged and Mount Pleasant	—85	35	25.78
Z	Mount Blue to Ragged	300	44	02.91
dZ		+	50	03.88
180°		180		
Z′	Ragged to Mount Blue	121	34	06.79

	°	′	″			°	′	″
L	44	43	41.437	Mount Blue.	M	70	20	33.157
dL	—	30	56.052	110743.7 meters.*	dM	— 1	11	27.830
L′	44	12	45.385	Ragged.	M′	69	09	05.327

K	5.0443191	K²	10.08864			h	3.2633
cos Z	9.7084678	sin² Z	9.86854	$(\delta L)^2$	6.5372	K² sin² Z	9.9572
B	8.5104887	C	1.39991	D	2.3933	E	6.2069
h	3.2632756		1.35709		8.9305		9.4274
	″		″				
1st term	+1833.478	3d term	+0.0852			dM^2	10.897_n
2d term	+ 22.756	4th term	—0.2675			F	7.844
	+1856.234						8.741_n
3d and 4th terms	— 0.182						
		K	5.0443191				
—dL	+1856.052	sin Z	9.9342701_n	Arg.		dM	3.632237_n
λ	44° 28′ 13″.4	A′	8.5090107	K	—218	sin λ	9.845433
½dL	0 15 28.0	cos L′ ar. co.	0.1446280	dM_n	+314	cos ½ dL ar. co.	0.000004
			3.6322375_n	corr.	+ 96		3.477674_n
							″
		dM	—4287.″830			—dZ	—3003.82
						2d term	— 0.06
						—dZ	—3003.88

* 68.8 st. miles nearly.

L. M. Z.—FORM FOR SUBORDINATE TRIANGULATION.

		°	′	″
Z	Tomales Bay to Sonoma	244	08	30.9
∠	Bodega and Sonoma	— 83	14	34.7
Z	Tomales Bay to Bodega	160	53	56.2
dZ		—	2	01.9
180°		180		
Z′	Bodega to Tomales Bay	340	51	54.3

	°	′	″			°	′	″
L	38	10	47.982	Tomales Bay.	M	122	56	47.301
dL	+	7	28.222	14626.8 meters.	dM	+	3	16.993
L′	38	18	16.204	Bodega.	M′	123	00	04.294

° ′ ″ λ=38 14 32		K	4.1651480	K^2	8.3303	h^2	5.303
		cos Z	9.9754055n	$\sin^2 Z$	9.0297	D	2.380
		B	8.5109892	C	1.3003		
1st term	″ —448.273	h	2.6515427n		8.6603		7.683
2d and 3d terms	+ 0.051				0.046		0.005
—dL	—448.222	K	4.1651480				
		sin Z	9.5148602				
		A′	8.5091611	dM	2.29445		
		cos L′ ar. comp.	0.1052810	sin λ	9.79168		
			2.2944503		2.08613		
		dM	″ + 196.993	—dZ	″ + 121.9		

The inverse problem.—There are cases when it is required to compute the distance and azimuth between two points that are given by their latitudes and longitudes. This problem is of comparatively rare occurrence, and it has not been found necessary to construct special formulæ and blank forms for it since it can readily be solved by using those provided for the case heretofore treated. This is done by dividing $d\,M=K \sin Z \,.\, A' \sec L'$ by the first term for dL, $h=K \cos Z \,.\, B$, when we get, $\tan Z=\frac{dM}{A' \sec L'} \cdot \frac{B}{h}$ which would give us the azimuth at once if we knew h, dM being given. We therefore seek to compute the smaller terms for the difference of latitude, in order to obtain h by subtracting them from the known dL. The only addition to the usual form is the term, $\log \tan Z=\log (K \sin Z)-\log (K \cos Z)$. K will best be taken from the term h when sin Z is greater than cos Z, and from the term dM when the reverse is the case. When the distance K is large, as in primary triangulation, it will be necessary to introduce the correction for dM due to difference of ratio between sine and arc, using the form for primary L. M. Z. inversely, as indicated above.

L. M. Z.—FORM FOR INVERSE SOLUTION.

		°	′	″
Z	to			
∠	and			
Z	Tomales Bay to Bodega	160	53	56.2
dZ		—	2	01.9
180°		180		
Z′	Bodega to Tomales Bay	340	51	54.3

	°	′	″			°	′	″
L	38	10	47.982	Tomales Bay.	M	122	56	47.301
dL	+	7	28.222	14626.8 meters.	dM		3	16.993
L′	38	18	16.204	Bodega.	M′	123	00	04.294

$\lambda=38°\ 14'\ 32''$		K cos Z	4.1405535_n	K² sin² Z	7.3600	h²	5.303
		B.	8.5109892	C	1.3003	D	2.380
1st term	−448″.273	h	2.6515427_n		8.6603		7.683
2d and 3d terms	+ 0.051				0.046		0.005
−dL	−448.222	K sin Z	3.6800082			K sin Z	3.6800082
						K cos Z	4.1405535_n
		A′	8.5091611	dM	2.29445	tan Z	9.5394547_n
		cos L′ ar. comp.	0.1052810	sin λ	9.79168	Z	160° 53′ 56″.2
			2.2944503		2.08613	sin Z	9.5148602
		dM	+196″.993	−dZ	+121″.9	K	4.1651480

Log. factors A, B, C, D and E between latitudes 23° *and* 65°.

[Based on the Clarke spheroid of 1866.]

LATITUDE **23°**

Lat.	log **A** diff. 1″ = − 0.05	log **B** diff. 1″ = − 0.16	log **C** diff. 1″ = + 0.57	log **D** diff. 1″ = + 0.04	log **E** diff. 1″ = + 0.04
° ′					
23 00	8.509 5021	8.512 0026	1.03390	2.2487	5.7997
1	17	17	425	90	99
2	14	08	460	92	5.8002
3	11	8.511 9998	495	95	04
4	08	89	530	97	07
05	05	80	565	2.2500	09
6	02	71	600	02	12
7	8.509 4999	61	634	05	14
8	96	52	669	07	16
9	93	43	704	09	19
10	8.509 4990	8.511 9934	1.03739	2.2512	5.8021
11	87	24	774	14	24
12	83	15	809	17	26
13	80	06	843	19	29
14	77	8.511 9896	878	21	31
15	74	87	913	24	34
16	71	78	947	26	36
17	68	68	982	29	39
18	65	59	1.04017	31	41
19	62	50	052	34	44
20	8.509 4959	8.511 9840	1.04086	2.2536	5.8046
21	55	31	121	38	49
22	52	22	155	41	51
23	49	12	190	43	54
24	46	03	224	45	56
25	43	8.511 9794	259	48	59
26	40	84	293	50	61
27	37	75	328	53	64
28	34	66	362	55	66
29	31	56	397	57	69
30	8.509 4927	8.511 9747	1.04431	2.2560	5.8071
31	24	37	466	62	74
32	21	28	500	64	76
33	18	19	534	67	79
34	15	09	569	69	81
35	12	00	603	71	84
36	09	8.511 9690	637	74	86
37	05	81	672	76	89
38	02	71	706	79	91
39	8.509 4899	62	740	81	93
40	8.509 4896	8.511 9653	1.04775	2.2583	5.8096
41	93	43	809	86	99
42	90	34	843	88	5.8101
43	87	24	877	90	04
44	83	15	911	93	06
45	80	05	945	95	09
46	77	8.511 9596	980	97	11
47	74	86	1.05014	2.2600	14
48	71	77	048	02	16
49	68	67	082	04	19
50	8.509 4865	8.511 9558	1.05116	2.2606	5.8121
51	61	48	150	08	24
52	58	39	184	11	26
53	55	29	218	13	29
54	52	20	252	16	31
55	49	10	286	18	34
56	45	01	320	20	36
57	42	8.511 9491	354	23	39
58	39	82	388	25	41
59	36	72	422	27	44
60	8.509 4833	8.511 9463	1.05456	2.2629	5.8146

LATITUDE 24°

Lat.	log **A** diff. 1″=−0.05	log **B** diff. 1″=−0.16	log **C** diff. 1″=+0.56	log **D** diff. 1″=+0.04	log **E** diff. 1″=+0.04
° ′					
24 00	8. 509 4833	8. 511 9463	1. 05456	2. 2629	5. 8146
1	30	53	490	32	49
2	26	44	523	34	51
3	23	34	557	36	54
4	20	24	591	39	57
05	17	15	625	41	59
6	14	05	658	43	62
7	10	8. 511 9396	692	45	64
8	07	86	726	48	67
9	04	77	760	50	69
10	8. 509 4801	8. 511 9367	1. 05794	2. 2652	5. 8172
11	8. 509 4798	58	827	54	74
12	94	48	861	57	77
13	91	38	894	59	79
14	88	29	928	61	82
15	85	19	962	63	85
16	82	09	995	66	87
17	78	00	1. 06029	68	90
18	75	8. 511 9290	062	70	92
19	72	81	096	72	95
20	8. 509 4769	8. 511 9271	1. 06130	2. 2675	5. 8197
21	66	61	163	77	5. 8200
22	62	52	197	79	02
23	59	42	230	81	05
24	56	32	263	84	07
25	53	23	297	86	10
26	50	13	330	88	13
27	46	03	364	90	15
28	43	8. 511 9194	397	92	18
29	40	84	431	95	20
30	8. 509 4737	8. 511 9174	1. 06464	2. 2697	5. 8223
31	33	65	497	99	25
32	30	55	530	2. 2701	28
33	27	45	564	03	31
34	24	35	597	06	33
35	20	26	630	08	36
36	17	16	664	10	38
37	14	06	697	12	41
38	11	8. 511 9096	730	14	43
39	07	87	763	17	46
40	8. 509 4704	8. 511 9077	1. 06797	2. 2719	5. 8249
41	01	67	830	21	51
42	8. 509 4698	58	863	23	54
43	94	48	896	25	56
44	91	38	929	27	59
45	88	28	962	30	61
46	85	18	995	32	64
47	81	09	1. 07028	34	67
48	78	8. 511 8999	061	36	69
49	75	89	095	38	72
50	8. 509 4672	8. 511 8979	1. 07128	2. 2740	5. 8274
51	68	70	161	43	77
52	65	60	194	45	80
53	62	50	226	47	82
54	59	40	259	49	85
55	55	30	292	51	87
56	52	21	325	53	90
57	49	11	358	55	92
58	45	01	391	58	95
59	42	8. 511 8891	424	60	98
60	8. 509 4639	8. 511 8881	1. 07457	2. 2762	5. 8300

LATITUDE 25°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.16	log **C** diff. 1″ = +0.54	log **D** diff. 1″ = +0.03	log **E** diff. 1″ = +0.04
° ′					
25 00	8.509 4639	8.511 8881	1.07457	2.2762	5.8300
1	36	71	490	64	03
2	32	62	523	66	05
3	29	52	555	68	08
4	26	42	588	70	11
05	23	32	621	72	13
6	19	22	654	75	16
7	16	12	687	77	18
8	13	02	719	79	21
9	09	8.511 8793	752	81	24
10	8.509 4606	8.511 8783	1.07785	2.2783	5.8326
11	03	73	817	85	29
12	00	63	850	87	32
13	8.509 4596	53	883	89	34
14	93	43	915	91	37
15	90	33	948	93	39
16	86	23	981	96	42
17	83	13	1.08013	98	45
18	80	04	046	2.2800	47
19	76	8.511 8694	078	02	50
20	8.509 4573	8.511 8684	1.08111	2.2804	5.8352
21	70	74	143	06	55
22	66	64	176	08	59
23	63	54	208	10	60
24	60	44	241	12	63
25	56	34	273	14	66
26	53	24	306	16	68
27	50	14	338	18	71
28	46	04	370	20	73
29	43	8.511 8594	403	23	76
30	8.509 4540	8.511 8584	1.08435	2.2825	5.8379
31	37	74	468	27	81
32	33	64	500	29	84
33	30	54	532	31	87
34	26	44	565	33	89
35	23	34	597	35	92
36	20	24	629	37	94
37	17	14	662	39	97
38	13	04	694	41	5.8400
39	10	8.511 8494	726	43	02
40	8.509 4507	8.511 8484	1.08758	2.2845	5.8405
41	03	74	791	47	08
42	00	64	823	49	10
43	8.509 4496	54	855	51	13
44	93	44	887	53	16
45	90	34	919	55	18
46	86	24	951	57	21
47	83	14	984	59	24
48	80	04	1.09016	61	26
49	76	8.511 8393	048	63	29
50	8.509 4473	8.511 8383	1.09080	2.2865	5.8431
51	70	73	112	67	34
52	66	63	144	69	37
53	63	53	176	71	39
54	60	43	208	73	42
55	56	33	240	75	45
56	53	23	272	77	47
57	50	13	304	79	50
58	46	03	336	81	53
59	43	8.511 8293	368	83	55
60	8.509 4439	8.511 8283	1.09400	2.2885	5.8458

LATITUDE 26°

Lat.	log **A** diff. 1″ = − 0.06	log **B** diff. 1″ = − 0.17	log **C** diff. 1″ = + 0.52	log **D** diff. 1″ = + 0.03	log **E** diff. 1″ = + 0.04
° ′					
26 00	8.509 4439	8.511 8283	1.09400	2.2885	5.8458
1	36	72	432	87	61
2	33	62	464	89	63
3	29	52	496	91	66
4	26	42	527	93	69
05	22	32	559	95	71
6	19	22	591	97	74
7	16	12	623	99	77
8	12	01	655	2.2901	79
9	09	8.511 8191	687	03	82
10	8.509 4406	8.511 8181	1.09718	2.2905	5.8485
11	02	71	750	07	88
12	8.509 4399	61	782	09	90
13	95	51	814	11	93
14	92	40	845	13	96
15	88	30	877	15	98
16	85	20	909	17	5.8501
17	82	10	940	19	04
18	78	00	972	20	06
19	75	8.511 8089	1.10004	22	09
20	8.509 4372	8.511 8079	1.10036	2.2924	5.8512
21	68	69	067	26	14
22	65	59	099	28	17
23	61	48	130	30	20
24	58	38	162	32	22
25	54	28	194	34	25
26	51	18	225	36	28
27	48	08	257	38	30
28	44	8.511 7997	288	40	33
29	41	87	320	42	36
30	8.509 4337	8.511 7977	1.10351	2.2944	5.8539
31	34	67	383	46	41
32	31	56	414	47	44
33	27	46	446	49	47
34	24	36	477	51	49
35	20	25	509	53	52
36	17	15	540	55	55
37	13	05	571	57	57
38	10	8.511 7895	603	59	60
39	07	84	634	61	63
40	8.509 4303	8.511 7874	1.10666	2.2963	5.8566
41	00	64	697	65	68
42	8.509 4296	53	728	66	71
43	93	43	760	68	74
44	89	33	791	70	76
45	86	22	822	72	79
46	83	12	854	74	82
47	79	02	885	76	85
48	76	8.511 7791	916	78	87
49	72	81	947	80	90
50	8.509 4269	8.511 7771	1.10979	2.2981	5.8593
51	65	60	1.11010	83	95
52	62	50	041	85	98
53	58	40	072	87	5.8601
54	55	29	103	89	04
55	52	19	134	91	06
56	48	09	166	93	09
57	45	8.511 7698	197	94	12
58	41	88	228	96	14
59	38	77	259	98	17
60	8.509 4234	8.511 7667	1.11290	2.3000	5.8620

LATITUDE 27°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.18	log **C** diff. 1″ = +0.51	log **D** diff. 1″ = +0.03	log **E** diff. 1″ = +0.05
° ′					
27 00	8.509 4234	8.511 7667	1.11290	2.3000	5.8620
1	31	57	321	02	23
2	27	46	352	04	25
3	24	36	383	06	28
4	20	25	414	07	31
05	17	15	445	09	34
6	13	05	476	11	36
7	10	8.511 7594	507	13	39
8	06	84	538	15	42
9	03	73	569	17	44
10	8.509 4200	8.511 7563	1.11600	2.3018	5.8647
11	8.509 4196	53	631	20	50
12	93	42	662	22	53
13	89	32	693	24	55
14	86	21	724	26	58
15	82	11	755	27	61
16	79	00	786	29	64
17	75	8.511 7490	817	31	66
18	72	79	848	33	69
19	68	69	878	35	72
20	8.509 4165	8.511 7458	1.11909	2.3037	5.8675
21	61	48	940	38	77
22	58	37	971	40	80
23	54	27	1.12002	42	83
24	51	16	032	44	86
25	47	06	063	45	88
26	44	8.511 7395	094	47	91
27	40	85	125	49	94
28	37	74	156	51	97
29	33	64	186	53	99
30	8.509 4130	8.511 7353	1.12217	2.3054	5.8702
31	26	43	248	56	05
32	23	32	278	58	08
33	19	22	309	60	10
34	16	11	340	61	13
35	12	01	370	63	16
36	08	8.511 7290	401	65	19
37	05	80	432	67	22
38	01	69	462	69	24
39	8.509 4098	58	493	70	27
40	8.509 4094	8.511 7248	1.12523	2.3072	5.8730
41	91	37	554	74	33
42	87	27	584	76	35
43	84	16	615	77	38
44	80	06	646	79	41
45	77	8.511 7195	676	81	44
46	73	84	707	83	46
47	70	74	737	84	49
48	66	63	768	86	52
49	63	53	798	88	55
50	8.509 4059	8.511 7142	1.12829	2.3090	5.8757
51	56	31	859	91	60
52	52	21	889	93	63
53	49	10	920	95	66
54	45	00	950	96	69
55	41	8.511 7089	981	98	72
56	38	78	1.13011	2.3100	74
57	34	68	041	02	77
58	31	57	072	03	80
59	27	46	102	05	83
60	8.509 4024	8.511 7036	1.13132	2.3107	5.8785

LATITUDE 28°

Lat.	log A diff. 1″ = −0.06	log B diff. 1″ = −0.18	log C diff. 1″ = +0.50	log D diff. 1″ = +0.03	log E diff. 1″ = +0.05
° ′					
28 00	8.509 4024	8.511 7036	1.13132	2.3107	5.8785
1	20	25	163	09	88
2	17	14	193	10	91
3	13	04	223	12	94
4	10	8.511 6993	254	14	97
05	06	82	284	15	99
6	02	72	314	17	5.8802
7	8.509 3999	61	345	19	05
8	95	50	375	20	08
9	92	40	405	22	11
10	8.509 3988	8.511 6929	1.13435	2.3124	5.8813
11	85	18	465	26	16
12	81	08	496	27	19
13	78	8.511 6897	526	29	22
14	74	86	556	31	25
15	70	75	586	32	27
16	67	65	616	34	30
17	63	54	646	36	33
18	60	43	677	37	36
19	56	33	707	39	39
20	8.509 3952	8.511 6822	1.13737	2.3141	5.8841
21	49	11	767	42	44
22	45	00	797	44	47
23	4[illegible]	8.511 6790	827	46	50
24	38	79	857	47	53
25	35	68	887	49	55
26	31	57	917	51	58
27	27	47	947	52	61
28	24	36	977	54	64
29	20	25	1.14007	56	67
30	8.509 3917	8.511 6714	1.14037	2.3157	5.8870
31	13	04	067	59	72
32	09	8.511 6693	097	61	75
33	06	82	127	62	78
34	02	71	157	64	81
35	8.509 3899	61	187	66	84
36	95	50	217	67	87
37	92	39	247	69	89
38	88	28	277	70	92
39	84	17	307	72	95
40	8.509 3881	8.511 6607	1.14337	2.3174	5.8898
41	77	8.511 6596	366	75	5.8901
42	73	85	396	77	04
43	70	74	426	79	06
44	66	63	456	80	09
45	63	52	486	82	12
46	59	42	516	83	15
47	55	31	545	85	18
48	52	20	575	87	21
49	48	09	605	88	23
50	8.509 3845	8.511 6498	1.14635	2.3190	5.8926
51	41	87	664	92	29
52	37	76	694	93	32
53	34	66	724	95	35
54	30	55	754	96	38
55	26	44	783	98	40
56	23	33	813	2.3200	43
57	19	22	843	01	46
58	16	11	872	03	49
59	12	00	902	04	52
60	8.509 3808	8.511 6389	1.14932	2.3206	5.8955

LATITUDE 29°

Lat.	log A diff. 1″ = − 0.06	log B diff. 1″ = − 0.18	log C diff. 1″ = + 0.49	log D diff. 1″ = + 0.03	log E diff. 1″ = + 0.05
° ′					
29 00	8. 509 3808	8. 511 6389	1. 14932	2. 3206	5. 8955
1	05	78	961	08	58
2	01	68	991	09	60
3	8. 509 3797	57	1. 15021	11	63
4	94	46	050	12	66
05	90	35	080	14	69
6	86	24	109	15	72
7	83	13	139	17	75
8	79	02	168	19	78
9	76	8. 511 6291	198	20	80
10	8. 509 3772	8. 511 6280	1. 15228	2. 3222	5. 8983
11	68	69	257	23	86
12	65	58	287	25	89
13	61	47	316	26	92
14	57	36	346	28	95
15	54	26	375	30	98
16	50	15	405	31	5. 9000
17	46	04	434	33	03
18	43	8. 511 6193	464	34	06
19	39	82	493	36	09
20	8. 509 3735	8. 511 6171	1. 15522	2. 3237	5. 9012
21	32	60	552	39	15
22	28	49	581	40	18
23	24	38	611	42	21
24	21	27	640	43	23
25	17	16	670	45	26
26	13	05	699	47	29
27	10	8. 511 6094	728	48	32
28	06	83	758	50	35
29	02	72	787	51	38
30	8. 509 3699	8. 511 6061	1. 15816	2. 3253	5. 9041
31	95	50	846	54	43
32	91	39	875	56	46
33	88	28	904	57	49
34	84	17	934	59	52
35	80	06	963	60	55
36	77	8. 511 5995	992	62	58
37	73	84	1. 16021	63	61
38	69	73	051	65	64
39	66	61	080	66	67
40	8. 509 3662	8. 511 5950	1. 16109	2. 3268	5. 9069
41	58	39	138	69	72
42	55	28	167	71	75
43	51	17	197	72	78
44	47	06	226	74	81
45	44	8. 511 5895	255	75	84
46	40	84	284	77	87
47	36	73	313	78	90
48	33	62	343	80	93
49	29	51	372	81	96
50	8. 509 3625	8. 511 5840	1. 16401	2. 3283	5. 9098
51	21	29	430	84	5. 9101
52	18	18	459	86	04
53	14	06	488	87	07
54	10	8. 511 5795	517	89	10
55	07	84	546	90	13
56	03	73	575	92	16
57	8. 509 3599	62	604	93	19
58	96	51	633	95	22
59	92	40	663	96	25
60	8. 509 3588	8. 511 5729	1. 16692	2. 3298	5. 9127

LATITUDE **30°**

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.19	log **C** diff. 1″ = +0.48	log **D** diff. 1″ = +0.02	log **E** diff. 1″ = +0.05
° ′					
30 00	8.509 3588	8.511 5729	1.16692	2.3298	5.9127
1	84	18	721	99	30
2	81	06	750	2.3301	33
3	77	8.511 5695	778	02	36
4	73	84	807	04	39
05	69	73	836	05	42
6	66	62	865	06	45
7	62	51	894	08	48
8	58	40	923	09	51
9	55	28	952	11	54
10	8.509 3551	8.511 5617	1.16981	2.3312	5.9157
11	47	06	1.17010	14	59
12	43	8.511 5595	039	15	62
13	40	84	068	17	65
14	36	73	097	18	68
15	32	61	126	19	71
16	29	50	155	21	74
17	25	39	184	22	77
18	21	28	212	24	80
19	17	17	241	25	83
20	8.509 3514	8.511 5505	1.17270	2.3327	5.9186
21	10	8.511 5494	299	28	89
22	06	83	328	30	92
23	02	72	357	31	95
24	8.509 3499	61	385	32	98
25	95	49	414	34	5.9200
26	91	38	443	35	03
27	88	27	472	37	06
28	84	16	500	38	09
29	80	04	529	39	12
30	8.509 3476	8.511 5393	1.17558	2.3341	5.9215
31	72	82	587	42	18
32	69	71	615	44	21
33	65	59	644	45	24
34	61	48	673	47	27
35	57	37	701	48	30
36	54	26	730	49	33
37	50	14	759	51	36
38	46	03	788	52	39
39	42	8.511 5292	816	54	42
40	8.509 3439	8.511 5281	1.17845	2.3355	5.9245
41	35	69	874	56	48
42	31	58	902	58	51
43	27	47	931	59	53
44	24	35	959	60	56
45	20	24	988	62	59
46	16	13	1.18017	63	62
47	12	02	045	65	65
48	09	8.511 5190	074	66	68
49	05	79	102	67	71
50	8.509 3401	8.511 5168	1.18131	2.3368	5.9274
51	8.509 3397	56	160	70	77
52	94	45	188	71	80
53	90	34	217	73	83
54	86	22	245	74	86
55	82	11	274	76	89
56	78	00	302	77	92
57	75	8.511 5088	331	78	95
58	71	77	359	80	98
59	67	66	388	81	5.9301
60	8.509 3363	8.511 5054	1.18416	2.3382	5.9304

LATITUDE 31°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.19	log **C** diff. 1″ = +0.47	log **D** diff. 1″ = +0.02	log **E** diff. 1″ = +0.05
° ′					
31 00	8.509 3363	8.511 5054	1.18416	2.3382	5.9304
1	60	43	445	84	07
2	56	32	473	85	10
3	52	20	501	86	13
4	48	09	530	88	16
05	44	8.511 4998	558	89	19
6	41	86	587	90	22
7	37	75	615	92	25
8	33	64	643	93	28
9	29	52	672	95	31
10	8.509 3325	8.511 4941	1.18700	2.3396	5.9334
11	22	29	729	97	37
12	18	18	757	99	39
13	14	07	785	2.3400	42
14	10	8.511 4895	813	01	45
15	06	84	842	02	48
16	03	72	870	04	51
17	8.509 3299	61	898	05	54
18	95	50	927	06	57
19	91	38	955	08	60
20	8.509 3287	8.511 4827	1.18983	2.3409	5.9363
21	84	15	1.19012	10	66
22	80	04	040	12	69
23	76	8.511 4793	068	13	72
24	72	81	096	14	75
25	68	70	125	16	78
26	65	58	153	17	81
27	61	47	181	18	84
28	57	35	209	20	87
29	53	24	238	21	90
30	8.509 3249	8.511 4713	1.19266	2.3422	5.9393
31	46	01	294	23	96
32	42	8.511 4690	322	25	99
33	38	78	351	26	5.9402
34	34	67	379	27	05
35	30	55	407	29	08
36	26	44	435	30	11
37	23	32	463	31	14
38	19	21	491	33	17
39	15	09	520	34	20
40	8.509 3211	8.511 4598	1.19548	2.3435	5.9423
41	07	86	576	36	26
42	03	75	604	38	29
43	00	63	632	39	32
44	8.509 3196	52	660	40	35
45	92	40	688	41	38
46	88	29	716	43	41
47	84	17	744	44	44
48	81	06	772	45	47
49	77	8.511 4494	800	47	50
50	8.509 3173	8.511 4483	1.19828	2.3448	5.9453
51	69	71	856	49	56
52	65	60	884	50	59
53	61	48	912	52	62
54	57	37	940	53	65
55	54	25	968	54	68
56	50	14	996	55	72
57	46	02	1.20024	57	75
58	42	8.511 4391	052	58	78
59	38	79	080	59	81
60	8.509 3134	8.511 4368	1.20108	2.3460	5.9484

LATITUDE 32°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.19	log **C** diff. 1″ = +0.46	log **D** diff. 1″ = +0.02	log **E** diff. 1″ = +0.05
° ′					
32 00	8.509 3134	8.511 4368	1.20108	2.3460	5.9484
1	31	56	136	62	87
2	27	44	164	63	90
3	23	33	192	64	93
4	19	21	220	65	96
05	15	10	248	67	99
6	11	8.511 4298	276	68	5.9502
7	07	87	304	69	05
8	04	75	332	70	08
9	00	63	360	71	11
10	8.509 3096	8.511 4252	1.20387	2.3473	5.9514
11	92	40	415	74	17
12	88	29	443	75	20
13	84	17	471	76	23
14	80	05	499	78	26
15	76	8.511 4194	527	79	29
16	73	82	555	80	32
17	67	71	582	81	35
18	65	59	610	82	38
19	61	47	638	84	41
20	8.509 3057	8.511 4136	1.20666	2.3485	5.9544
21	53	24	694	86	47
22	49	13	722	87	50
23	46	01	749	88	53
24	42	8.511 4089	777	90	56
25	38	78	805	91	60
26	34	66	833	92	63
27	30	54	860	93	66
28	26	43	888	94	69
29	22	31	916	96	72
30	8.509 3018	8.511 4020	1.20944	2.3497	5.9575
31	15	08	971	98	78
32	11	8.511 3996	999	99	81
33	07	85	1.21027	2.3500	84
34	03	73	054	02	87
35	8.509 2999	61	082	03	90
36	95	50	110	04	93
37	91	38	137	05	96
38	87	26	165	06	99
39	83	15	193	07	5.9602
40	8.509 2980	8.511 3903	1.21220	2.3509	5.9605
41	76	8.511 3891	248	10	08
42	72	79	276	11	11
43	68	68	303	12	15
44	64	56	331	13	18
45	60	44	358	14	21
46	56	33	386	16	24
47	52	21	414	17	27
48	48	09	441	18	30
49	44	8.511 3798	469	19	33
50	8.509 2940	8.511 3786	1.21496	2.3520	5.9636
51	37	74	524	21	39
52	33	63	551	23	42
53	29	51	579	24	45
54	25	39	607	25	48
55	21	27	634	26	51
56	17	16	662	27	54
57	13	04	689	28	58
58	09	8.511 3692	717	29	61
59	05	80	744	31	64
60	8.509 2901	8.511 3669	1.21772	2.3532	5.9667

LATITUDE 33°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.20	log **C** diff. 1″ = +0.45	log **D** diff. 1″ = +0.02	log **E** diff. 1″ = +0.05
° ′					
33 00	8.509 2901	8.511 3669	1.21772	2.3532	5.9667
1	8.509 2897	57	799	23	70
2	94	45	827	34	73
3	90	33	854	35	76
4	86	22	882	36	79
05	82	10	909	37	82
6	78	8.511 3598	937	38	85
7	74	86	964	40	88
8	70	75	992	41	92
9	66	63	1.22019	42	95
10	8.509 2862	8.511 3551	1.22047	2.3543	5.9698
11	58	39	074	44	5.9701
12	54	28	101	45	04
13	51	16	129	46	07
14	47	04	156	47	10
15	43	8.511 3492	184	49	13
16	39	80	211	50	16
17	35	69	238	51	19
18	31	57	266	52	22
19	27	45	293	53	26
20	8.509 2823	8.511 3433	1.22321	2.3554	5.9729
21	19	21	348	55	32
22	15	10	375	56	35
23	11	8.511 3398	403	57	38
24	07	86	430	58	41
25	03	74	457	60	44
26	8.509 2799	62	485	61	47
27	95	51	512	62	50
28	91	39	539	63	53
29	88	27	567	64	57
30	8.509 2784	8.511 3315	1.22594	2.3565	5.9760
31	80	03	621	66	63
32	76	8.511 3291	648	67	66
33	72	80	676	68	69
34	68	68	703	69	72
35	64	56	730	70	75
36	60	44	757	71	78
37	56	32	785	73	81
38	52	20	812	74	85
39	48	09	839	75	88
40	8.509 2744	8.511 3197	1.22866	2.3576	5.9791
41	40	85	893	77	94
42	36	73	921	78	97
43	32	61	948	79	5.9800
44	28	49	975	80	03
45	24	37	1.23002	81	06
46	20	25	029	82	10
47	16	13	057	83	13
48	12	02	084	84	16
49	08	8.511 3090	111	85	19
50	8.509 2704	8.511 3078	1.23138	2.3586	5.9822
51	01	66	165	87	25
52	8.509 2697	54	192	88	28
53	93	42	220	89	31
54	89	30	247	91	35
55	85	18	274	92	38
56	81	06	301	93	41
57	77	8.511 2995	328	94	44
58	73	83	355	95	47
59	69	71	382	96	50
60	8.509 2665	8.511 2959	1.23409	2.3597	5.9853

LATITUDE **34°**

Lat.	log **A** diff. 1″=−0.07	log **B** diff. 1″=−0.20	log **C** diff. 1″=+0.45	log **D** diff. 1″=+0.02	log **E** diff. 1″=+0.05
° ′					
34 00	8.509 2665	8.511 2959	1.23409	2.3597	5.9853
1	61	47	437	98	57
2	57	35	464	99	60
3	53	23	491	2.3600	63
4	49	11	518	01	66
05	45	8.511 2899	545	02	69
6	41	87	572	03	72
7	37	75	599	04	75
8	33	63	626	05	79
9	30	51	653	06	82
10	8.509 2625	8.511 2840	1.23680	2.3607	5.9885
11	21	28	707	08	88
12	17	16	734	09	91
13	13	04	761	10	94
14	09	8.511 2792	788	11	97
15	05	80	815	12	5.9901
16	01	68	842	13	04
17	8.509 2597	56	869	14	07
18	93	44	896	15	10
19	89	32	923	16	13
20	8.509 2585	8.511 2720	1.23950	2.3617	5.9916
21	81	08	977	18	19
22	77	8.511 2696	1.24004	19	23
23	73	84	031	20	26
24	69	72	058	21	29
25	65	60	085	22	32
26	61	48	112	23	35
27	57	36	139	24	38
28	53	24	165	25	42
29	49	12	192	26	45
30	8.509 2545	8.511 2600	1.24219	2.3627	5.9948
31	41	8.511 2588	246	28	51
32	37	76	273	29	54
33	33	64	300	30	57
34	29	52	327	31	61
35	25	40	354	32	64
36	21	28	381	33	67
37	17	16	408	34	70
38	13	04	434	35	73
39	09	8.511 2492	461	36	76
40	8.509 2505	8.511 2480	1.24488	2.3637	5.9980
41	01	68	515	38	83
42	8.509 2497	56	542	39	86
43	93	44	569	40	89
44	89	32	595	41	92
45	85	20	622	42	96
46	81	08	649	43	99
47	77	8.511 2396	676	44	6.0002
48	73	84	703	44	05
49	69	72	729	45	08
50	8.509 2465	8.511 2360	1.24756	2.3646	6.0011
51	61	48	783	47	15
52	57	35	810	48	18
53	53	23	837	49	21
54	49	11	863	50	24
55	45	8.511 2299	890	51	27
56	41	87	917	52	31
57	37	75	944	53	34
58	33	63	970	54	37
59	29	51	997	55	40
60	8.509 2425	2.511 2239	1.25024	2.3656	6.0043

LATITUDE 35°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.20	log C diff. 1″ = +0.44	log D diff. 1″ = +0.01	log E diff. 1″ = +0.05
° ′					
35 00	8. 509 2425	8. 511 2239	1. 25024	2. 3656	6. 0043
1	21	27	050	57	47
2	17	15	077	58	50
3	13	03	104	59	53
4	09	8. 511 2191	131	59	56
05	05	78	157	60	59
6	01	66	184	61	63
7	8. 509 2396	54	211	62	66
8	93	42	237	63	69
9	88	30	264	64	72
10	8. 509 2384	8. 511 2118	1. 25291	2. 3665	6. 0075
11	80	06	317	66	79
12	76	8. 511 2094	344	67	82
13	72	82	371	68	85
14	68	70	397	69	88
15	64	57	424	70	91
16	60	45	451	70	95
17	56	33	477	71	98
18	52	21	504	72	6. 0101
19	48	09	531	73	04
20	8. 509 2344	8. 511 1997	1. 25557	2. 3674	6. 0107
21	40	85	584	75	11
22	36	72	610	76	14
23	32	60	637	77	17
24	28	48	664	78	20
25	24	36	690	79	23
26	20	24	717	79	27
27	16	12	743	80	30
28	12	00	770	81	33
29	08	8. 511 1887	796	82	36
30	8. 509 2304	8. 511 1875	1 25823	2. 3683	6. 0140
31	00	63	850	84	43
32	8. 509 2296	51	876	85	46
33	92	39	903	86	49
34	87	27	929	86	52
35	83	15	956	87	56
36	79	02	982	88	59
37	75	8. 511 1790	1. 26009	89	62
38	71	78	035	90	65
39	67	66	062	91	69
40	8. 509 2263	8. 511 1754	1. 26088	2. 3692	6. 0172
41	59	41	115	93	75
42	55	29	141	93	78
43	51	17	168	94	81
44	47	05	194	95	85
45	43	8. 511 1693	221	96	88
46	39	80	247	97	91
47	35	68	274	98	94
48	31	56	300	99	98
49	27	44	327	99	6. 0201
50	8. 509 2222	8. 511 1632	1. 26353	2. 3700	6. 0204
51	18	20	380	01	07
52	14	07	406	02	11
53	10	8. 511 1595	432	03	14
54	06	83	459	04	17
55	02	71	485	05	20
56	8. 509 2198	58	512	05	24
57	94	46	538	06	27
58	90	34	565	07	30
59	86	22	591	08	33
60	8. 509 2182	8. 511 1510	1. 26617	2. 3709	6. 0237

LATITUDE 36°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.20	log **C** diff. 1″ = +0.44	log **D** diff. 1″ = +0.01	log **E** diff. 1″ = +0.05
° ′					
36 00	8.509 2182	8.511 1510	1.26617	2.3709	6.0237
1	78	8.511 1497	644	10	40
2	74	85	670	10	43
3	70	73	697	11	46
4	65	61	723	12	50
05	61	48	749	13	53
6	57	36	776	14	56
7	53	24	802	14	59
8	49	12	828	15	63
9	45	8.511 1399	855	16	66
10	8.509 2141	8.511 1387	1.26881	2.3717	6.0269
11	37	75	908	18	72
12	33	63	934	19	76
13	29	50	960	19	79
14	25	38	987	20	82
15	21	26	1.27013	21	85
16	16	14	039	22	89
17	12	01	066	23	92
18	08	8.511 1289	092	23	95
19	04	77	118	24	99
20	8.509 2100	8.511 1265	1.27145	2.3725	6.0302
21	8.509 2096	52	171	26	05
22	92	40	197	27	08
23	88	28	223	27	12
24	84	15	250	28	15
25	80	03	276	29	18
26	75	8.511 1191	302	30	21
27	71	79	329	31	25
28	67	66	355	31	28
29	63	54	381	32	31
30	8.509 2059	8.511 1142	1.27407	2.3733	6.0334
31	55	29	434	34	38
32	51	17	460	35	41
33	47	05	486	35	44
34	43	8.511 1092	512	36	48
35	39	80	539	37	51
36	35	68	565	38	54
37	30	56	591	38	57
38	26	43	617	39	61
39	22	31	644	40	64
40	8.509 2018	8.511 1019	1.27670	2.3741	6.0367
41	14	06	696	41	71
42	10	8.511 0994	722	42	74
43	06	82	748	43	77
44	02	69	775	44	80
45	8.509 1998	57	801	45	84
46	93	45	827	45	87
47	89	32	853	46	90
48	85	20	879	47	94
49	81	08	905	48	97
50	8.509 1977	8.511 0895	1.27932	2.3748	6.0400
51	73	83	958	49	03
52	69	71	984	50	07
53	65	58	1.28010	51	10
54	61	46	036	51	13
55	56	34	062	52	17
56	52	21	088	53	20
57	48	09	114	54	23
58	44	8.511 0797	141	54	27
59	40	84	167	55	30
60	8.509 1936	8.511 0772	1.28193	2.3756	6.0433

LATITUDE 37°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.21	log C diff. 1″ = +0.43	log D diff. 1″ = +0.01	log E diff. 1″ = +0.06
° ′					
37 00	8.509 1936	8.511 0772	1.28193	2.3756	6.0433
1	32	60	219	56	37
2	28	47	245	57	40
3	23	35	271	58	43
4	19	22	297	59	46
05	15	10	324	59	50
6	11	8.511 0698	350	60	53
7	07	85	376	61	56
8	03	73	402	62	60
9	8.509 1899	61	428	62	63
10	8.509 1895	8.511 0648	1.28454	2.3763	6.0466
11	90	36	480	64	70
12	86	23	506	65	73
13	82	11	532	65	76
14	78	8.511 0599	558	66	80
15	74	86	584	67	83
16	70	74	610	67	86
17	66	61	636	68	89
18	62	49	662	69	93
19	57	37	688	69	96
20	8.509 1853	8.511 0524	1.28715	2.3770	6.0499
21	49	12	741	71	6.0503
22	45	00	767	72	06
23	41	8.511 0487	793	72	09
24	37	75	819	73	13
25	33	62	845	74	16
26	28	50	871	74	19
27	24	37	897	75	23
28	20	25	923	76	26
29	16	13	949	76	29
30	8.509 1812	8.511 0400	1.28975	2.3777	6.0533
31	08	8.511 0388	1.29001	78	36
32	04	75	027	79	39
33	00	63	053	79	43
34	8.509 1795	51	079	80	46
35	91	38	104	81	49
36	87	26	130	81	53
37	83	13	156	82	56
38	79	01	182	83	59
39	75	8.511 0288	208	83	63
40	8.509 1771	8.511 0276	1.29234	2.3784	6.0566
41	66	64	260	85	69
42	62	51	286	85	73
43	58	39	312	86	76
44	54	26	338	87	79
45	50	14	364	87	83
46	46	01	390	88	86
47	41	8.511 0189	416	89	89
48	37	76	442	89	93
49	33	64	468	90	96
50	8.509 1729	8.511 0151	1.29494	2.3791	6.0600
51	25	39	520	91	03
52	21	26	546	92	06
53	16	14	571	93	10
54	12	02	597	93	13
55	08	8.511 0089	623	94	16
56	04	77	649	95	20
57	00	64	675	95	23
58	8.509 1696	52	701	96	26
59	92	39	727	96	30
60	8.509 1687	8.511 0027	1.29753	2.3797	6.0633

LATITUDE 38°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.21	log **C** diff. 1″ = +0.43	log **D** diff. 1″ = +0.01	log **E** diff. 1″ = +0.06
° ′					
38 00	8.509 1687	8.511 0027	1.29753	2.3797	6.0633
1	83	14	778	98	36
2	79	02	804	98	40
3	75	8.510 9989	830	99	43
4	71	77	856	2.3800	47
05	67	64	882	00	50
6	62	52	908	01	53
7	58	39	934	02	57
8	54	27	959	02	60
9	50	14	985	03	63
10	8.509 1646	8.510 9902	1.30011	2.3803	6.0667
11	42	8.510 9889	037	04	70
12	37	77	063	05	73
13	33	64	089	05	77
14	29	52	114	06	80
15	25	39	140	07	84
16	21	27	166	07	87
17	17	14	192	08	90
18	12	02	218	08	94
19	08	8.510 9789	243	09	97
20	8.509 1604	8.510 9777	1.30269	2.3810	6.0701
21	00	64	295	10	04
22	8.509 1596	52	321	11	07
23	92	39	347	12	11
24	87	27	372	12	14
25	83	14	398	13	17
26	79	01	424	13	21
27	75	8.510 9689	450	14	24
28	71	77	476	15	28
29	66	64	501	15	31
30	8.509 1562	8.510 9652	1.30527	2.3816	6.0734
31	58	39	553	16	38
32	54	27	579	17	41
33	50	14	604	17	44
34	46	01	630	18	48
35	41	8.510 9589	656	19	51
36	37	76	682	19	55
37	33	64	707	20	58
38	29	51	733	20	61
39	25	39	759	21	65
40	8.509 1521	8.510 9526	1.30785	2.3822	6.0768
41	16	14	810	22	72
42	12	01	836	23	75
43	08	8.510 9488	862	23	78
44	04	76	887	24	82
45	00	63	913	24	85
46	8.509 1495	51	939	25	89
47	91	38	965	26	92
48	87	26	990	26	95
49	83	13	1.31016	27	99
50	8.509 1479	8.510 9401	1.31042	2.3827	6.0802
51	75	8.510 9388	067	28	06
52	70	76	093	28	09
53	66	63	119	29	13
54	62	50	144	30	16
55	58	38	170	30	19
56	53	25	196	31	23
57	49	13	221	31	26
58	45	00	247	32	30
59	41	8.510 9287	273	32	33
60	8.509 1437	8.510 9275	1.31299	2.3833	6.0836

LATITUDE 39°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.21	log C diff. 1″ = +0.43	log D diff. 1″ = +0.01	log E diff. 1″ = +0.06
° ′					
39 00	8.509 1437	8.510 9275	1.31299	2.3833	6.0836
1	33	62	324	33	40
2	28	50	350	34	43
3	24	37	375	35	47
4	20	25	401	35	50
05	16	12	427	36	53
6	12	8.510 9199	452	36	57
7	07	87	478	37	60
8	03	74	504	37	64
9	8.509 1399	62	529	38	67
10	8.509 1395	8.510 9149	1.31555	2.3838	6.0871
11	91	36	581	39	74
12	86	24	606	39	77
13	82	11	632	2.3840	81
14	78	8.510 9098	658	40	84
15	74	86	683	41	88
16	70	73	709	41	91
17	65	61	734	42	95
18	61	48	760	43	98
19	57	36	786	43	6.0902
20	8.509 1353	8.510 9023	1.31811	2.3844	6.0905
21	49	10	837	44	08
22	44	8.510 8998	862	45	12
23	40	85	888	45	15
24	36	73	913	46	19
25	32	60	939	46	22
26	28	47	965	47	26
27	23	35	990	47	29
28	19	22	1.32016	48	32
29	15	09	041	48	36
30	8.509 1311	8.510 8897	1.32067	2.3849	6.0939
31	07	84	092	49	43
32	02	72	118	2.3850	46
33	8.509 1298	59	144	50	50
34	94	46	169	51	53
35	90	34	195	51	57
36	86	21	220	52	60
37	81	08	246	52	63
38	77	8.510 8796	271	53	67
39	73	83	297	53	70
40	8.509 1269	8.510 8771	1.32323	2.3854	6.0974
41	64	58	348	54	77
42	60	45	374	55	81
43	56	33	399	55	84
44	52	20	425	56	88
45	48	07	450	56	91
46	43	8.510 8695	476	57	95
47	39	82	501	57	98
48	35	69	527	57	6.1002
49	31	57	552	58	05
50	8.509 1227	8.510 8644	1.32578	2.3858	6.1008
51	22	31	603	59	12
52	18	19	629	59	15
53	14	06	654	2.3860	19
54	10	8.510 8593	680	60	22
55	06	81	705	61	26
56	01	68	731	61	29
57	8.509 1197	55	756	62	33
58	93	43	782	62	36
59	89	30	807	63	40
60	8.509 1184	8.510 8517	1.32833	2.3863	6.1043

LATITUDE **40°**

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.21	log **C** diff. 1″ = +0.42	log **D** diff. 1″ = +0.01	log **E** diff. 1″ = +0.06
° ′					
40 00	8.509 1184	8.510 8517	1.32833	2.3863	6.1043
1	80	05	858	64	47
2	76	8.510 8492	884	64	50
3	72	79	909	64	54
4	67	67	935	65	57
05	63	54	960	65	61
6	59	41	986	66	64
7	55	29	1.33011	66	67
8	50	16	037	67	71
9	46	03	062	67	74
10	8.509 1142	8.510 8391	1.33088	2.3868	6.1078
11	38	78	113	68	81
12	34	65	139	68	85
13	29	53	164	69	88
14	25	40	189	69	92
15	21	27	215	2.3870	95
16	17	15	240	70	99
17	12	02	266	71	6.1102
18	08	8.510 8289	291	71	06
19	04	77	317	72	09
20	8.509 1100	8.510 8264	1.33342	2.3872	6.1113
21	8.509 1096	51	368	72	16
22	91	38	393	73	20
23	87	26	418	73	23
24	83	13	444	74	27
25	79	00	469	74	30
26	74	8.510 8188	495	74	34
27	70	75	520	75	37
28	66	62	546	75	41
29	62	50	571	76	44
30	8.509 1057	8.510 8137	1.33596	2.3876	6.1148
31	53	24	622	77	51
32	49	11	647	77	55
33	45	8.510 8099	673	77	58
34	41	86	698	78	62
35	36	73	723	78	65
36	32	61	749	79	69
37	28	48	774	79	72
38	24	35	800	79	76
39	19	23	825	2.3880	79
40	8.509 1015	8.510 8010	1.33850	2.3880	6.1183
41	11	8.510 7997	876	81	86
42	07	84	901	81	90
43	02	72	926	81	93
44	8.509 0998	59	952	82	97
45	94	46	977	82	6.1200
46	90	33	1.34003	83	04
47	85	21	028	83	07
48	81	08	053	83	11
49	77	8.510 7895	079	84	15
50	8.509 0973	8.510 7883	1.34104	2.3884	6.1218
51	68	70	129	84	22
52	64	57	155	85	25
53	60	44	180	85	29
54	56	32	206	86	32
55	52	19	231	86	36
56	47	06	256	86	39
57	43	8.510 7793	282	87	43
58	39	81	307	87	46
59	34	68	332	87	50
60	8.509 0930	8.510 7755	1.34358	2.3888	6.1253

LATITUDE 41°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.21	log C diff. 1″ = +0.42	log D diff. 1″ = +0.01	log diff. 1″ = +0.06
° ′					
41 00	8.509 0930	8.510 7755	1.34358	2.3888	6.1253
1	26	42	383	88	57
2	22	30	408	89	60
3	18	17	434	89	64
4	13	04	459	89	67
05	09	8.510 7691	484	90	71
6	05	79	510	90	75
7	00	66	535	90	78
8	8.509 0896	53	560	91	82
9	92	40	586	91	85
10	8.509 0888	8.510 7628	1.34611	2.3891	6.1289
11	83	15	636	92	92
12	79	02	662	92	96
13	75	8.510 7590	687	93	99
14	71	77	712	93	6.1303
15	67	64	738	93	06
16	62	51	763	94	10
17	58	39	788	94	14
18	54	26	814	94	17
19	49	13	839	95	21
20	8.509 0845	8.510 7500	1.34864	2.3895	6.1324
21	41	8.510 7488	890	95	28
22	37	75	915	96	31
23	32	62	940	96	35
24	28	49	965	96	38
25	24	36	991	97	42
26	20	24	1.35016	97	46
27	15	11	041	97	49
28	11	8.510 7398	066	98	53
29	07	85	092	98	56
30	8.509 0803	8.510 7373	1.35117	2.3898	6.1360
31	8.509 0798	60	142	99	63
32	94	47	168	99	67
33	90	34	193	99	70
34	86	22	218	2.3900	74
35	81	09	243	00	78
36	77	8.510 7296	269	00	81
37	73	83	294	00	85
38	69	70	319	01	88
39	64	58	345	01	92
40	8.509 0760	8.510 7245	1.35370	2.3901	6.1395
41	56	32	395	02	99
42	52	19	420	02	6.1403
43	47	07	446	02	06
44	43	8.510 7194	471	03	10
45	39	81	496	03	13
46	35	68	522	03	17
47	30	55	547	03	20
48	26	43	572	04	24
49	22	30	597	04	28
50	8.509 0718	8.510 7117	1.35623	2.3904	6.1431
51	13	04	648	05	35
52	09	8.510 7091	673	05	38
53	05	79	698	05	42
54	00	66	723	05	46
55	8.509 0696	53	749	06	49
56	92	40	774	06	53
57	88	27	799	06	56
58	83	15	824	07	60
59	79	02	850	07	63
60	8.509 0675	8.510 6989	1.35875	2.3907	6.1467

LATITUDE 42°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.21	log C diff. 1″ = +0.42	log D diff. 1″ = +0.00	log E diff. 1″ = +0.06
° ′					
42 00	8.509 0675	8.510 6989	1.35875	2.3907	6.1467
1	71	70	900	08	71
2	66	64	925	08	74
3	62	51	951	08	78
4	58	38	976	08	81
05	54	25	1.36001	09	85
6	49	12	026	09	89
7	45	00	052	09	92
8	41	8.510 6887	077	09	96
9	36	74	102	10	99
10	8.509 0632	8.510 6861	1.36127	2.3910	6.1503
11	28	48	152	10	07
12	24	36	178	10	10
13	19	23	203	11	14
14	15	10	228	11	17
15	11	8.510 6797	253	11	21
16	07	84	278	12	25
17	02	72	304	12	28
18	8.509 0598	59	329	12	32
19	94	46	354	12	35
20	8.509 0590	8.510 6733	1.36379	2.3913	6.1539
21	85	20	404	13	43
22	81	07	430	13	46
23	77	8.510 6695	455	13	50
24	72	82	480	13	54
25	68	69	505	14	57
26	64	56	530	14	61
27	60	43	556	14	64
28	55	31	581	14	68
29	51	18	606	15	72
30	8.509 0547	8.510 6605	1.36631	2.3915	6.1575
31	43	8.510 6592	656	15	79
32	38	79	682	15	83
33	34	66	707	16	86
34	30	54	732	16	90
35	25	41	757	16	93
36	21	28	782	16	97
37	17	15	808	17	6.1601
38	13	02	833	17	04
39	08	8.510 6490	858	17	08
40	8.509 0504	8.510 6477	1.36883	2.3917	6.1612
41	00	64	908	17	15
42	8.509 0496	51	934	18	19
43	91	38	959	18	22
44	87	25	984	18	26
45	83	13	1.37009	18	30
46	78	00	034	19	33
47	74	8.510 6387	059	19	37
48	70	74	085	19	41
49	66	61	110	19	44
50	8.509 0461	8.510 6348	1.37135	2.3919	6.1648
51	57	36	160	20	52
52	53	23	185	20	55
53	48	10	210	20	59
54	44	8.510 6297	235	20	63
55	40	84	261	20	66
56	36	71	286	21	70
57	31	59	311	21	73
58	27	46	336	21	77
59	23	33	361	21	81
60	8.509 0419	8.510 6220	1.37386	2.3921	6.1684

ERRATUM.

(At foot of page 350.)

In column Log B, second line, for 70 read 76.

LATITUDE 43°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.21	log **C** diff. 1″ = +0.42	log **D** diff. 1″ = +0.00	log **E** diff. 1″ = +0.06
° ′					
43 00	8.509 0419	8.510 6220	1.37386	2.3921	6.1684
1	14	07	412	22	88
2	10	8.510 6195	437	22	92
3	06	82	462	22	95
4	01	69	487	22	99
05	8.509 0397	56	512	22	6.1703
6	93	43	537	22	06
7	89	30	563	23	10
8	84	17	588	23	14
9	80	05	613	23	17
10	8.509 0376	8.510 6092	1.37638	2.3923	6.1721
11	71	79	663	23	25
12	67	66	688	24	28
13	63	53	713	24	32
14	59	40	739	24	36
15	54	28	764	24	39
16	50	15	789	24	43
17	46	02	814	24	47
18	41	8.510 5989	839	25	50
19	37	76	864	25	54
20	8.509 0333	8.510 5963	1.37889	2.3925	6.1758
21	29	50	915	25	61
22	24	38	940	25	65
23	20	25	965	25	69
24	16	12	990	25	72
25	12	8.510 5899	1.38015	26	76
26	07	86	040	26	80
27	03	73	065	26	83
28	8.509 0299	60	091	26	87
29	94	48	116	26	91
30	8.509 0290	8.510 5835	1.38141	2.3926	6.1795
31	86	22	166	27	98
32	82	09	191	27	6.1802
33	77	8.510 5796	216	27	06
34	73	83	241	27	09
35	69	71	266	27	13
36	64	58	292	27	17
37	60	45	317	27	20
38	56	32	342	27	24
39	52	19	367	28	28
40	8.509 0247	8.510 5706	1.38392	2.3928	6.1831
41	43	8.510 5693	417	28	35
42	39	81	442	28	39
43	34	68	467	28	42
44	30	55	492	28	46
45	26	42	518	28	50
46	22	29	543	28	53
47	17	16	568	29	57
48	13	03	593	29	61
49	09	8.510 5591	618	29	65
50	8.509 0204	8.510 5578	1.38643	2.3929	6.1868
51	00	65	668	29	72
52	8.509 0196	52	693	29	76
53	92	39	719	29	79
54	87	26	744	29	83
55	83	13	769	30	87
56	79	01	794	30	91
57	74	8.510 5488	819	30	94
58	70	75	844	30	98
59	66	62	869	30	6.1902
60	8.509 0162	8.510 5449	1.38894	2.3930	6.1905

LATITUDE 44°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.21	log **C** diff. 1″ = +0.42	log **D** diff. 1″ = +0.00	log **E** diff. 1″ = +0.06
° ′					
44 00	8.509 0162	8.510 5449	1.38894	2.3930	6.1905
1	57	36	919	30	09
2	53	23	945	30	13
3	49	01	970	30	17
4	44	8.510 5388	995	30	20
05	40	75	1.39020	31	24
6	36	62	045	31	28
7	31	49	070	31	31
8	27	36	095	31	35
9	23	23	120	31	39
10	8.509 0119	8.510 5311	1.39145	2.3931	6.1943
11	14	07	171	31	46
12	10	8.510 5295	196	31	50
13	06	82	221	31	54
14	02	69	246	31	58
15	8.509 0097	56	271	31	61
16	93	43	296	31	65
17	89	30	321	32	69
18	84	18	346	32	72
19	80	05	371	32	76
20	8.509 0076	8.510 5192	1.39396	2.3932	6.1980
21	72	79	422	32	84
22	67	66	447	32	87
23	63	53	472	32	91
24	59	40	497	52	95
25	54	28	522	32	99
26	50	15	547	32	6.2002
27	46	02	572	32	06
28	42	8.510 5089	597	32	10
29	37	76	623	32	14
30	8.509 0033	8.510 5063	1.39648	2.3932	6.2017
31	29	50	673	32	21
32	24	37	698	32	25
33	20	25	723	33	29
34	16	12	748	33	32
35	11	8.510 4999	773	33	36
36	07	86	798	33	40
37	03	73	823	33	44
38	8.508 9999	60	848	33	47
39	94	47	873	33	51
40	8.508 9990	8.510 4935	1.39898	2.3933	6.2055
41	86	22	924	33	59
42	81	09	949	33	62
43	77	8.510 4896	974	33	66
44	73	83	999	33	70
45	69	70	1.40024	33	74
46	64	57	049	33	77
47	60	44	074	33	81
48	56	32	099	33	85
49	51	19	124	33	89
50	8.508 9947	8.510 4806	1.40149	2.3933	6.2092
51	43	8.510 4793	174	33	96
52	39	80	200	33	6.2100
53	34	67	225	33	04
54	30	54	250	33	08
55	26	41	275	33	11
56	21	29	300	33	15
57	17	16	325	33	19
58	13	03	350	33	23
59	09	8.510 4690	375	33	27
60	8.508 9904	8.510 4677	1.40400	2.3933	6.2130

LATITUDE 45°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.21	log C diff. 1″ = +0.42	log D diff. 1″ = ±0.00	log E diff. 1″ = +0.06
° ′					
45 00	8.508 9904	8.510 4677	1.40400	2.3933	6.2130
1	00	64	425	33	34
2	8.508 9896	51	450	33	38
3	91	39	475	34	42
4	87	26	501	34	46
05	83	13	526	34	49
6	78	00	551	34	53
7	74	8.510 4587	576	34	57
8	70	74	601	34	61
9	66	61	626	34	64
10	8.508 9861	8.510 4548	1.40651	2.3934	6.2168
11	57	36	676	34	72
12	53	23	701	34	76
13	48	10	727	34	80
14	44	8.510 4497	752	34	83
15	40	84	777	33	87
16	36	71	802	33	91
17	31	59	827	33	95
18	27	46	852	33	99
19	23	33	877	33	02
20	8.508 9818	8.510 4420	1.40902	2.3933	6.2206
21	14	07	927	33	10
22	10	8.510 4394	952	33	14
23	06	81	978	33	18
24	01	68	1.41003	33	21
25	8.508 9797	56	028	33	25
26	93	43	053	33	29
27	88	30	078	33	33
28	84	17	103	33	37
29	80	04	128	33	40
30	8.508 9776	8.510 4291	1.41153	2.3933	6.2244
31	71	78	178	33	48
32	67	65	203	33	52
33	63	52	229	33	56
34	58	40	254	33	60
35	54	27	279	33	63
36	50	14	304	33	67
37	46	01	329	33	71
38	41	8.510 4188	354	33	75
39	37	75	379	33	79
40	8.508 9733	8.510 4162	1.41404	2.3933	6.2283
41	28	49	429	33	86
42	24	37	454	33	90
43	20	24	479	33	94
44	16	11	505	33	98
45	11	8.510 4098	530	33	6.2302
46	07	85	555	32	06
47	03	72	580	32	09
48	8.508 9698	60	605	32	13
49	94	47	630	32	17
50	8.508 9690	8.510 4034	1.41655	2.3932	6.2321
51	86	21	680	32	25
52	82	08	705	32	29
53	78	8.510 3995	731	32	32
54	74	82	756	32	36
55	68	69	781	32	40
56	64	57	806	32	44
57	60	44	831	32	48
58	55	31	856	32	52
59	51	18	881	32	55
60	8.508 9647	8.510 3905	1.41906	2.3932	6.2359

LATITUDE 46°

Lat.	log **A** diff. 1″ = −0.07	log diff. 1″ = −0.21	log **C** diff. 1″ = +0.42	log **D** diff. 1″ = −0.00	log diff. 1″ = +0.06
° ′					
46 00	8.508 9647	8.510 3905	1.41906	2.3932	6.2359
1	43	8.510 3892	931	32	63
2	38	79	957	31	67
3	34	67	982	31	71
4	30	54	1.42007	31	75
05	25	41	032	31	79
6	21	28	057	31	82
7	17	15	082	31	86
8	13	02	107	31	90
9	08	8.510 3789	132	31	94
10	8.508 9604	8.510 3776	1.42157	2.3931	6.2398
11	00	64	183	31	6.2402
12	8.508 9595	51	208	31	06
13	91	38	233	30	09
14	87	25	258	30	13
15	83	12	283	30	17
16	78	8.510 3699	308	30	21
17	74	86	333	30	25
18	70	74	358	30	29
19	65	61	384	30	33
20	8.508 9561	8.510 3648	1.42409	2.3930	6.2436
21	57	35	434	30	40
22	53	22	459	30	44
23	48	09	484	29	48
24	44	8.510 3596	509	29	52
25	40	84	534	29	56
26	35	71	559	29	60
27	31	58	584	29	64
28	27	45	610	29	67
29	23	32	635	29	71
30	8.508 9518	8.510 3519	1.42660	2.3929	6.2475
31	14	06	685	29	79
32	10	8.510 3494	710	28	83
33	05	81	735	28	87
34	01	68	760	28	91
35	8.508 9497	55	786	28	95
36	93	42	811	28	99
37	88	29	836	28	6.2502
38	84	17	861	28	06
39	80	04	886	28	10
40	8.508 9475	8.510 3391	1.42911	2.3927	6.2514
41	71	78	936	27	18
42	67	65	961	27	22
43	63	52	987	27	26
44	58	39	1.43012	27	30
45	54	27	037	27	34
46	50	14	062	27	38
47	45	01	087	26	41
48	41	8.510 3288	112	26	45
49	37	75	137	26	49
50	8.508 9433	8.510 3262	1.43163	2.3926	6.2553
51	28	49	188	26	57
52	24	37	213	26	61
53	20	24	238	26	65
54	16	11	263	25	69
55	11	8.510 3198	288	25	73
56	07	85	314	25	77
57	03	72	339	25	81
58	8.508 9398	60	364	25	84
59	94	47	389	25	88
60	8.508 9390	8.510 3134	1.43414	2.3924	6.2592

LATITUDE 47°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.21	log **C** diff. 1″ = +0.42	log **D** diff. 1″ = −0.00	log **E** diff. 1″ = +0.07
° ′					
47 00	8.508 9390	8.510 3134	1.43414	2.3924	6.2592
1	86	21	439	24	96
2	81	08	465	24	6.2600
3	77	8.510 3095	490	24	04
4	73	82	515	24	08
05	68	70	540	24	12
6	64	57	565	23	16
7	60	44	590	23	20
8	56	31	615	23	24
9	51	18	641	23	28
10	8.508 9347	8.510 3005	1.43666	2.3923	6.2632
11	43	8.510 2993	691	23	35
12	38	80	716	22	39
13	34	67	741	22	43
14	30	54	766	22	47
15	26	41	792	22	51
16	21	28	817	22	55
17	17	16	842	21	59
18	13	03	867	21	63
19	09	8.510 2890	892	21	67
20	8.508 9304	8.510 2877	1.43917	2.3921	6.2671
21	00	64	943	21	75
22	8.508 9296	51	968	20	79
23	91	39	993	20	83
24	87	26	1.44018	20	87
25	83	13	043	20	91
26	79	00	069	20	95
27	74	8.510 2787	094	19	99
28	70	74	119	19	6.2702
29	66	62	144	19	06
30	8.508 9261	8.510 2749	1.44169	2.3919	6.2710
31	57	36	195	19	14
32	53	23	220	18	18
33	49	10	245	18	22
34	44	8.510 2698	270	18	26
35	40	85	295	18	30
36	36	72	321	18	34
37	32	59	346	17	38
38	27	46	371	17	42
39	23	33	396	17	46
40	8.508 9219	8.510 2621	1.44421	2.3917	6.2750
41	14	08	447	16	54
42	10	8.510 2595	472	16	58
43	06	82	497	16	62
44	02	69	522	16	66
45	8.508 9197	57	547	16	70
46	93	44	573	15	74
47	89	31	598	15	78
48	84	18	623	15	82
49	80	05	648	15	86
50	8.508 9176	8.510 2493	1.44673	2.3914	6.2790
51	72	80	699	14	94
52	67	67	724	14	98
53	63	54	749	14	6.2802
54	59	41	774	13	06
55	55	28	800	13	10
56	50	16	825	13	14
57	46	03	850	13	18
58	42	8.510 2390	875	12	22
59	38	77	900	12	26
60	8.508 9133	8.510 2364	1.44926	2.3912	6.2830

LATITUDE 48°

Lat.	log A diff. 1″=−0.07	log B diff. 1″=−0.21	log C diff. 1″=+0.42	log D diff. 1″=−0.00	log E diff. 1″=+0.07
° ′					
48 00	8. 508 9133	8. 510 2364	1. 44926	2. 3912	6. 2830
1	29	52	951	12	34
2	25	39	976	11	38
3	20	26	1. 45001	11	42
4	16	13	027	11	46
05	12	00	052	11	50
6	08	8. 510 2288	077	10	54
7	03	75	102	10	58
8	8. 508 9099	62	128	10	62
9	95	49	153	10	66
10	8. 508 9091	8. 510 2236	1. 45178	2. 3909	6. 2870
11	86	24	203	09	74
12	82	11	229	09	78
13	78	8. 510 2198	254	08	82
14	74	85	279	08	86
15	69	72	304	08	90
16	65	60	330	08	94
17	61	47	355	07	98
18	57	34	380	07	6. 2902
19	52	21	406	07	06
20	8. 508 9048	8. 510 2108	1. 45431	2. 3907	6. 2910
21	44	8. 510 2096	456	06	14
22	39	83	481	06	18
23	35	70	507	06	22
24	31	57	532	05	26
25	27	45	557	05	30
26	22	32	582	05	34
27	18	19	608	05	38
28	14	06	633	04	42
29	10	8. 510 1993	658	04	46
30	8. 508 9005	8. 510 1981	1. 45683	2. 3904	6. 2950
31	01	68	709	03	54
32	8. 508 8997	55	734	03	58
33	93	42	759	03	62
34	88	30	785	02	66
35	84	17	810	02	70
36	80	04	835	02	74
37	76	8. 510 1891	861	02	78
38	71	78	886	01	82
39	67	66	911	01	86
40	8. 508 8963	8. 510 1853	1. 45937	2. 3901	6. 2990
41	59	40	962	00	94
42	54	27	987	00	98
43	50	15	1. 46012	00	6. 3002
44	46	02	038	2. 3899	06
45	41	8. 510 1789	063	99	10
46	37	76	088	99	15
47	33	64	114	98	19
48	29	51	139	98	23
49	24	38	164	98	27
50	8. 508 8920	8. 510 1725	1. 46190	2. 3897	6. 3031
51	16	13	215	97	35
52	12	00	240	97	39
53	08	8. 510 1687	266	96	43
54	03	74	291	96	47
55	8. 508 8899	62	316	96	51
56	95	49	342	95	55
57	90	36	367	95	59
58	86	23	392	95	63
59	82	10	418	94	67
60	8. 508 8878	8. 510 1598	1. 46443	2. 3894	6. 3071

LATITUDE 49°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.21	log C diff. 1″ = +0.42	log D diff. 1″ = −0.01	log E diff. 1″ = +0.07
° ′					
49 00	8. 508 8878	8. 510 1598	1. 46443	2. 3894	6. 3071
1	73	85	468	94	75
2	69	72	494	93	79
3	65	59	519	93	84
4	61	47	544	93	88
05	57	34	570	92	92
6	52	21	595	92	96
7	48	08	621	92	6. 3100
8	44	8. 510 1496	646	91	04
9	39	83	671	91	08
10	8. 508 8835	8. 510 1470	1. 46696	2. 3891	6. 3112
11	31	58	722	90	16
12	27	45	747	90	20
13	23	32	773	2. 3889	24
14	18	19	798	89	28
15	14	07	824	89	32
16	10	8. 510 1394	849	88	37
17	06	81	874	88	41
18	01	68	899	88	45
19	8. 508 8797	56	925	87	49
20	8. 508 8793	8. 510 1343	1. 46950	2. 3887	6. 3153
21	89	30	976	87	57
22	84	17	1. 47001	86	61
23	80	05	026	86	65
24	76	8. 510 1292	052	85	69
25	72	79	077	85	73
26	67	67	103	85	78
27	63	54	128	84	82
28	59	41	153	84	86
29	55	28	179	83	90
30	8. 508 8750	8. 510 1216	1. 47204	2. 3883	6. 3194
31	46	03	230	83	98
32	42	8. 510 1190	255	82	6. 3202
33	38	78	281	82	06
34	33	65	306	82	10
35	29	52	331	81	15
36	25	39	357	81	19
37	21	27	382	80	23
38	16	14	408	80	27
39	12	01	433	80	31
40	8. 508 8708	8. 510 1088	1. 47459	2. 3879	6. 3235
41	04	76	484	79	39
42	00	63	509	78	43
43	8. 508 8695	50	535	78	47
44	91	38	560	78	52
45	87	25	586	77	56
46	83	12	611	77	60
47	78	00	637	76	64
48	74	8. 510 0987	662	76	68
49	70	74	688	75	72
50	8. 508 8666	8. 510 0962	1. 47713	2. 3875	6. 3276
51	61	49	738	75	81
52	57	36	764	74	85
53	53	23	789	74	89
54	49	11	815	73	93
55	45	8. 510 0898	840	73	97
56	40	85	866	73	6. 3301
57	36	73	891	72	05
58	32	60	917	72	09
59	28	48	942	71	14
60	8. 508 8623	8. 510 0835	1. 47968	2. 3871	6. 3318

LATITUDE 50°

Lat.	log A	log B	log C	log D	log E
	diff. 1″ = −0.07	diff. 1″ = −0.21	diff. 1″ = −0.43	diff. 1″ = −0.01	diff. 1″ = +0.07
° ′					
50 0	8. 508 8623	8. 510 0835	1. 47968	2. 3871	6. 3318
1	19	22	993	70	22
2	15	09	1. 48019	70	26
3	11	8. 510 0797	044	70	30
4	06	84	070	69	34
05	02	71	095	69	39
6	8. 508 8598	59	121	68	43
7	94	46	146	68	47
8	90	33	172	67	51
9	85	21	197	67	55
10	8. 508 8581	8. 510 0708	1. 48223	2. 3866	6. 3359
11	77	8. 510 0695	248	66	63
12	73	83	274	66	68
13	68	70	299	65	72
14	64	57	325	65	76
15	60	45	350	64	80
16	56	32	376	64	84
17	52	19	401	63	88
18	47	07	427	63	93
19	43	8. 510 0594	452	62	97
20	8. 508 8539	8. 510 0581	1. 48478	2. 3862	6. 3401
21	35	69	504	61	05
22	30	56	529	61	09
23	26	43	555	60	14
24	22	31	580	60	18
25	18	18	606	60	22
26	14	05	631	59	26
27	09	8. 510 0493	657	59	30
28	05	80	682	58	34
29	01	67	708	58	39
30	8. 508 8497	8. 510 0455	1. 48734	2. 3857	6. 3443
31	93	42	759	57	47
32	88	29	785	56	51
33	84	17	810	56	55
34	80	04	836	55	60
35	76	8. 510 0392	861	55	64
36	71	79	887	54	68
37	67	66	913	54	72
38	63	54	938	53	76
39	59	41	964	53	81
40	8. 508 8455	8. 510 0328	1. 48989	2. 3852	6. 3485
41	50	16	1. 49015	52	89
42	46	03	041	51	93
43	42	8. 510 0291	066	51	97
44	38	78	092	50	6. 3502
45	34	65	117	50	06
46	29	53	143	49	10
47	25	40	169	49	14
48	21	27	194	48	18
49	17	15	220	48	23
50	8. 508 8413	8. 510 0202	1. 49246	2. 3847	6. 3527
51	08	8. 510 0190	271	47	31
52	04	77	297	46	35
53	00	64	322	46	40
54	8. 508 8396	52	348	45	44
55	92	39	374	45	48
56	87	27	399	44	52
57	83	14	425	44	56
58	79	01	451	43	61
59	75	8. 510 0089	476	43	65
60	8. 508 8371	8. 510 0076	1. 49502	2. 3842	6. 3569

LATITUDE 51°

Lat.	log A diff. 1″ = −0.07	log B diff. 1″ = −0.21	log C diff. 1″ = +0.43	log D diff. 1″ = −0.01	log E diff. 1″ = +0.07
° ′					
51 00	8.508 8371	8.510 0076	1.49502	2.3842	6.3569
1	66	64	528	41	73
2	62	51	553	41	78
3	58	38	579	40	82
4	54	26	605	40	86
05	50	13	630	39	90
6	45	01	656	39	95
7	41	8.509 9988	682	38	99
8	37	75	707	38	6.3603
9	33	63	733	37	07
10	8.508 8329	8.509 9951	1.49759	2.3837	6.3612
11	24	38	785	36	16
12	20	25	810	36	20
13	16	13	836	35	24
14	12	00	862	35	28
15	08	8.509 9887	887	34	33
16	03	75	913	34	37
17	8.508 8299	62	939	33	41
18	95	50	965	32	45
19	91	37	990	32	50
20	8.508 8287	8.509 9825	1.50016	2.3831	6.3654
21	82	12	042	31	58
22	78	8.509 9799	067	30	63
23	74	87	093	30	67
24	70	74	119	29	71
25	66	62	145	29	75
26	62	49	170	28	80
27	57	37	196	27	84
28	53	24	222	27	88
29	49	11	248	26	92
30	8.508 8245	8.509 9699	1.50273	2.3826	6.3697
31	41	86	299	25	6.3701
32	36	74	325	25	05
33	32	61	351	24	10
34	28	49	376	23	14
35	24	36	402	23	18
36	20	24	428	22	22
37	16	11	454	22	27
38	11	8.509 9599	480	21	31
39	07	86	505	20	35
40	8.508 8203	8.509 9574	1.50531	2.3820	6.3740
41	8.508 8199	61	557	19	44
42	95	48	583	19	48
43	90	36	609	18	52
44	86	23	634	18	57
45	82	11	660	17	61
46	78	8.509 9498	686	16	65
47	74	86	712	16	70
48	70	73	738	15	74
49	65	61	764	15	78
50	8.508 8161	8.509 9448	1.50789	2.3814	6.3782
51	57	36	815	13	87
52	53	23	841	13	91
53	49	11	867	12	95
54	45	8.509 9398	893	12	6.3800
55	40	86	919	11	04
56	36	73	944	10	08
57	32	61	970	10	13
58	28	48	996	09	17
59	24	36	1.51022	08	21
60	8.508 8120	8.509 9323	1.51048	2.3808	6.3826

LATITUDE 52°

Lat.	log A diff. 1″=−0.07	log B diff. 1″=−0.21	log C diff. 1″=+0.43	log D diff. 1″=−0.01	log E diff. 1″=+0.07
° ′					
52 00	8.508 8120	8.509 9323	1.51048	2.3808	6.3826
1	15	11	074	07	30
2	11	8.509 9298	100	07	34
3	07	86	126	06	39
4	03	73	151	05	43
05	8.508 8099	61	177	05	47
6	95	48	203	04	52
7	90	36	229	04	56
8	86	23	255	03	60
9	82	11	281	02	65
10	8.508 8078	8.509 9198	1.51307	2.3802	6.3869
11	74	86	333	01	73
12	70	73	359	00	78
13	65	61	385	00	82
14	61	48	411	2.3799	86
15	57	36	436	98	91
16	53	23	462	98	95
17	49	11	488	97	99
18	45	8.509 9099	514	97	6.3904
19	41	86	540	96	08
20	8.508 8036	8.509 9074	1.51566	2.3795	6.3912
21	32	61	592	95	17
22	28	49	618	94	21
23	24	36	644	93	25
24	20	24	670	93	30
25	16	11	696	92	34
26	11	8.509 8999	722	91	38
27	07	86	748	91	43
28	03	74	774	90	47
29	8.508 7999	62	800	89	51
30	8.508 7995	8.509 8949	1.51826	2.3789	6.3956
31	91	37	852	88	60
32	87	24	878	87	65
33	82	12	904	87	69
34	78	8.509 8899	930	86	73
35	74	87	956	85	78
36	70	74	982	85	82
37	66	62	1.52008	84	86
38	62	50	034	83	91
39	58	37	060	83	95
40	8.508 7953	8.509 8825	1.52086	2.3782	6.4000
41	49	12	112	81	04
42	45	00	138	81	08
43	41	8.509 8788	164	80	13
44	37	75	190	79	17
45	33	63	216	78	21
46	29	50	242	78	26
47	24	38	268	77	30
48	20	25	294	76	35
49	16	13	320	76	39
50	8.508 7912	8.509 8701	1.52347	2.3775	6.4043
51	08	8.509 8688	373	74	48
52	04	76	399	74	52
53	00	63	425	73	57
54	8.508 7895	51	451	72	61
55	91	39	477	72	65
56	87	26	503	71	70
57	83	14	529	70	74
58	79	02	555	69	79
59	75	8.509 8589	581	69	83
60	8.508 7871	8.509 8577	1.52608	2.3768	6.4088

LATITUDE 53°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.21	log **C** diff. 1″ = +0.44	log **D** diff. 1″ = −0.01	log **E** diff. 1″ = +0.07
° ′					
53 00	8.508 7871	8.509 8577	1.52608	2.3768	6.4088
1	67	64	634	67	92
2	62	52	660	67	96
3	58	40	686	66	6.4101
4	54	27	712	65	05
05	50	15	738	64	10
6	46	02	764	64	14
7	42	8.509 8490	790	63	18
8	38	78	817	62	23
9	34	65	843	62	27
10	8.508 7829	8.509 8453	1.52869	2.3761	6.4132
11	25	41	895	60	36
12	21	28	921	59	41
13	17	16	947	59	45
14	13	04	974	58	49
15	09	8.509 8391	1.53000	57	54
16	05	79	026	56	58
17	01	67	052	56	63
18	8.508 7797	54	078	55	67
19	92	42	105	54	72
20	8.508 7788	8.509 8329	1.53131	2.3753	6.4176
21	84	17	157	53	80
22	80	05	183	52	85
23	76	8.509 8292	209	51	89
24	72	80	236	50	94
25	68	68	262	50	98
26	64	55	288	49	6.4203
27	60	43	314	48	07
28	55	31	341	47	12
29	51	18	367	47	16
30	8.508 7747	8.509 8206	1.53393	2.3746	6.4221
31	43	8.509 8194	419	45	25
32	39	82	446	44	29
33	35	69	472	44	34
34	31	57	498	43	38
35	27	45	524	42	43
36	23	32	551	41	47
37	18	20	577	41	52
38	14	08	603	40	56
39	10	8.509 8095	630	39	61
40	8.508 7706	8.509 8083	1.53656	2.3738	6.4265
41	02	71	682	37	70
42	8.508 7698	58	709	37	74
43	94	46	735	36	79
44	90	34	761	35	83
45	86	22	788	34	88
46	82	09	814	34	92
47	77	8.509 7997	840	33	97
48	73	85	867	32	6.4301
49	69	72	893	31	06
50	8.508 7665	8.509 7960	1.53919	2.3730	6.4310
51	61	48	946	30	15
52	57	36	972	29	19
53	53	23	998	28	24
54	49	11	1.54025	27	28
55	45	8.509 7899	051	26	33
56	41	87	077	26	37
57	37	74	104	25	42
58	32	62	130	24	46
59	28	50	157	23	51
60	8.508 7624	8.509 7838	1.54183	2.3722	6.4355

LATITUDE 54°

Lat.	log **A** diff. 1″ = − 0.07	log **B** diff. 1″ = − 0.20	log **C** diff. 1″ = + 0.44	log **D** diff. 1″ = − 0.01	log **E** diff. 1″ = + 0.08
° ′					
54 00	8. 508 7624	8. 509 7838	1. 54183	2. 3722	6. 4355
1	20	25	209	22	60
2	16	13	236	21	64
3	12	01	262	20	69
4	08	8. 509 7789	288	19	73
05	04	76	315	18	78
6	00	64	341	18	82
7	8. 508 7596	52	368	17	87
8	92	40	394	16	91
9	88	27	421	15	96
10	8. 508 7584	8. 509 7715	1. 54447	2. 3714	6. 4400
11	79	03	474	13	05
12	75	8. 509 7691	500	13	09
13	71	78	527	12	14
14	67	66	553	11	18
15	63	54	580	10	23
16	59	42	606	09	28
17	55	30	633	08	32
18	51	17	659	08	37
19	47	05	686	07	41
20	8. 508 7543	8. 509 7593	1. 54712	2. 3706	6. 4446
21	39	81	739	05	50
22	35	69	765	04	55
23	31	56	792	03	59
24	27	44	818	02	64
25	22	32	845	02	68
26	18	20	871	01	73
27	14	08	898	00	78
28	10	8. 509 7495	924	2. 3699	82
29	06	83	951	98	87
30	8. 508 7502	8. 509 7471	1. 54977	2. 3697	6. 4491
31	8. 508 7498	59	1. 55004	97	96
32	94	47	031	96	6. 4500
33	90	34	057	95	05
34	86	22	084	94	09
35	82	10	110	93	14
36	78	8. 509 7398	137	92	19
37	74	86	163	91	23
38	70	74	190	90	28
39	66	61	217	90	32
40	8. 508 7462	8. 509 7349	1. 55243	2. 3689	6. 4537
41	58	37	270	88	41
42	53	25	297	87	46
43	49	13	323	86	51
44	45	01	350	85	55
45	41	8. 509 7289	376	84	60
46	37	76	403	83	64
47	33	64	430	83	69
48	29	52	456	82	74
49	25	40	483	81	78
50	8. 508 7421	8. 509 7228	1. 55510	2. 3680	6. 4583
51	17	16	536	79	87
52	13	04	563	78	92
53	09	8. 509 7191	590	77	97
54	05	79	616	76	6. 4601
55	01	67	643	75	06
56	8. 508 7397	55	670	75	10
57	93	43	696	74	15
58	89	31	723	73	20
59	85	19	750	72	24
60	8. 508 7381	8. 509 7107	1. 55777	2. 3671	6. 4629

LATITUDE **55°**

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.20	log **C** diff. 1″ = +0.45	log **D** diff. 1″ = −0.02	log **E** diff. 1″ = +0.08
° ′					
55 00	8.508 7381	8.509 7107	1.55777	2.3671	6.4629
1	77	8.509 7095	803	70	33
2	73	82	830	69	38
3	69	70	857	68	43
4	65	58	884	67	47
05	61	46	910	66	52
6	56	34	937	65	57
7	52	22	964	65	61
8	48	10	991	64	66
9	44	8.509 6998	1.56017	63	70
10	8.508 7340	8.509 6986	1.56044	2.3662	6.4675
11	36	74	071	61	80
12	32	62	098	60	84
13	28	49	125	59	89
14	24	37	151	58	94
15	20	25	178	57	98
16	16	13	205	56	6.4703
17	12	01	232	55	08
18	08	8.509 6889	259	54	12
19	04	77	286	53	17
20	8.508 7300	8.509 6865	1.56312	2.3652	21
21	8.508 7296	53	339	51	26
22	92	41	366	51	31
23	88	29	393	50	35
24	84	17	420	49	40
25	80	05	447	48	6.4745
26	76	8.509 6793	474	47	49
27	72	81	500	46	54
28	68	69	527	45	59
29	64	57	554	44	63
30	8.508 7260	8.509 6745	1.56581	2.3643	68
31	56	33	608	42	73
32	52	21	635	41	77
33	48	09	662	40	82
34	44	8.509 6696	689	39	87
35	40	84	716	38	6.4791
36	36	72	743	37	96
37	32	60	770	36	6.4801
38	28	48	797	35	05
39	24	36	823	34	10
40	8.508 7220	8.509 6624	1.56850	2.3633	6.4815
41	16	12	877	32	20
42	12	00	904	31	24
43	08	8.509 6588	931	30	29
44	04	76	958	29	34
45	00	64	985	28	38
46	8.508 7196	52	1.57012	27	43
47	92	40	039	26	48
48	88	28	066	25	52
49	84	16	093	24	57
50	8.508 7180	8.509 6505	1.57120	2.3623	6.4862
51	76	8.509 6493	147	22	66
52	72	81	174	21	71
53	68	69	201	20	76
54	64	57	229	19	81
55	60	45	256	18	85
56	56	33	283	17	90
57	52	21	310	16	95
58	48	09	337	15	6.4900
59	44	8.509 6397	364	14	04
60	8.508 7140	8.509 6385	1.57391	2.3613	6.4909

LATITUDE 56°

Lat.	log **A** diff. 1″ = −0.07	log **B** diff. 1″ = −0.20	log **C** diff. 1″ = +0.45	log **D** diff. 1″ = −0.02	log **E** diff. 1″ = +0.08
° ′					
56 00	8.508 7140	8.509 6385	1.57391	2.3613	6.4909
1	36	73	418	12	14
2	32	61	445	11	18
3	28	49	472	10	23
4	24	37	499	09	28
05	20	25	526	08	33
6	16	13	554	07	37
7	12	01	581	06	42
8	08	8.509 6289	608	05	47
9	04	77	635	04	52
10	8.508 7100	8.509 6266	1.57662	2.3603	6.4956
11	8.508 7096	54	689	02	61
12	92	42	717	01	66
13	88	30	744	00	71
14	84	18	771	2.3599	75
15	80	06	798	98	80
16	76	8.509 6194	825	97	85
17	72	82	852	96	90
18	69	70	880	95	94
19	65	58	907	94	99
20	8.508 7061	8.509 6147	1.57934	2.3593	6.5004
21	57	35	961	92	09
22	53	23	989	91	13
23	49	11	1.58016	90	18
24	45	8.509 6099	043	89	23
25	41	87	070	88	28
26	37	75	098	87	32
27	33	63	125	86	37
28	29	51	152	84	42
29	25	40	179	83	47
30	8.508 7021	8.509 6028	1.58207	2.3582	6.5052
31	17	16	234	81	56
32	13	04	261	80	61
33	09	8.509 5992	289	79	66
34	05	80	316	78	71
35	01	68	343	77	75
36	8.508 6997	57	371	76	80
37	93	45	398	75	85
38	89	33	425	74	90
39	86	21	453	73	95
40	8.508 6982	8.509 5909	1.58480	2.3572	6.5099
41	78	8.509 5897	507	71	6.5104
42	74	86	535	70	09
43	70	74	562	68	14
44	66	62	589	67	19
45	62	50	617	66	24
46	58	38	644	65	28
47	54	27	672	64	33
48	50	15	699	63	38
49	46	03	726	62	43
50	8.508 6942	8.509 5791	1.58754	2.3561	6.5148
51	38	79	781	60	52
52	34	67	809	59	57
53	30	56	836	58	62
54	26	44	864	56	67
55	23	32	891	55	72
56	19	20	919	54	77
57	15	09	946	53	81
58	11	8.509 5697	974	52	86
59	07	85	1.59001	51	91
60	8.508 6903	8.509 5673	1.59028	2.3550	6.5196

LATITUDE 57°

Lat.	log **A** diff. 1″=−0.06	log **B** diff. 1″=−0.19	log **C** diff. 1″=+0.46	log **D** diff. 1″=−0.02	log **E** diff. 1″=+0.08
° ′					
57 00	8.508 6903	8.509 5673	1.59028	2.3550	6.5196
1	8.508 6899	61	056	49	6.5201
2	95	50	083	48	06
3	91	38	111	46	10
4	87	26	139	45	15
05	83	14	166	44	20
6	79	03	194	43	25
7	75	8.509 5591	221	42	30
8	72	79	249	41	35
9	68	67	276	40	40
10	8.508 6864	8.509 5556	1.59304	2.3539	6.5244
11	60	44	331	37	49
12	56	32	359	36	54
13	52	20	387	35	59
14	48	09	414	34	64
15	44	8.509 5497	442	33	69
16	40	85	469	32	74
17	36	73	497	31	79
18	32	62	525	29	83
19	28	50	552	28	88
20	8.508 6825	8.509 5438	1.59580	2.3527	6.5293
21	21	27	608	26	98
22	17	15	635	25	6.5303
23	13	03	663	24	08
24	09	8.509 5392	691	23	13
25	05	80	718	21	18
26	01	68	746	20	22
27	8.508 6797	56	774	19	27
28	93	45	801	18	32
29	90	33	829	17	37
30	8.508 6786	8.509 5321	1.59857	2.3516	6.5342
31	82	10	885	14	47
32	78	8.509 5298	912	13	52
33	74	86	940	12	57
34	70	75	968	11	62
35	66	63	996	10	67
36	62	51	1.60023	09	72
37	58	40	051	07	76
38	54	28	079	06	81
39	51	16	107	05	86
40	8.508 6747	8.509 5205	1.60134	2.3504	6.5391
41	43	8.509 5193	162	03	96
42	39	81	190	01	6.5401
43	35	70	218	00	06
44	31	58	246	2.3499	11
45	27	46	274	98	16
46	23	35	301	97	21
47	20	23	329	96	26
48	16	12	357	94	31
49	12	00	385	93	36
50	8.508 6708	8.509 5088	1.60413	2.3492	6.5441
51	04	77	441	91	46
52	00	65	469	89	50
53	8.508 6696	54	496	88	55
54	92	42	524	87	60
55	89	30	552	86	65
56	85	19	580	85	70
57	81	07	608	83	75
58	77	8.509 4996	636	82	80
59	73	84	664	81	85
60	8.508 6669	8.509 4972	1.60692	2.3480	6.5490

LATITUDE 58°

Lat.	log A diff. 1″ = −0.06	log B diff. 1″ = −0.19	log C diff. 1″ = +0.47	log D diff. 1″ = −0.02	log E diff. 1″ = +0.08
° ′					
58 00	8.508 6669	8.509 4972	1.60692	2.3480	6.5490
1	65	61	720	79	95
2	62	49	748	77	6.5500
3	58	38	776	76	05
4	54	26	804	75	10
05	50	14	832	74	15
6	46	03	860	72	20
7	42	8.509 4891	888	71	25
8	38	80	916	70	30
9	35	68	944	69	35
10	8.508 6631	8.509 4857	1.60972	2.3467	6.5540
11	27	45	1.61000	66	45
12	23	33	028	65	50
13	19	22	056	64	55
14	15	10	084	63	60
15	11	8.509 4799	112	61	65
16	08	87	140	60	70
17	04	76	168	59	75
18	00	64	197	58	80
19	8.508 6596	53	225	56	85
20	8.508 6592	8.509 4741	1.61253	2.3455	6.5590
21	88	30	281	54	95
22	85	18	309	52	6.5600
23	81	07	337	51	05
24	77	8.509 4695	365	50	10
25	73	84	393	49	15
26	69	72	422	47	20
27	65	61	450	46	25
28	62	49	478	45	30
29	58	38	506	44	35
30	8.508 6554	8.509 4626	1.61534	2.3442	6.5640
31	50	15	563	41	45
32	46	03	591	40	50
33	42	8.509 4592	619	38	55
34	39	80	647	37	60
35	35	69	675	36	65
36	31	57	704	35	70
37	27	46	732	33	75
38	23	35	760	32	80
39	20	23	789	31	86
40	8.508 6516	8.509 4512	1.61817	2.3429	6.5691
41	12	00	845	28	96
42	08	8.509 4489	873	27	6.5701
43	04	77	902	26	06
44	00	66	930	24	11
45	8.508 6497	54	958	23	16
46	93	43	987	22	21
47	89	32	1.62015	20	26
48	85	20	043	19	31
49	81	09	072	18	36
50	8.508 6478	8.509 4397	1.62100	2.3416	6.5741
51	74	86	129	15	46
52	70	74	157	14	51
53	66	63	185	12	56
54	62	52	214	11	62
55	8.508 6459	40	242	10	67
56	55	29	271	09	72
57	51	17	299	07	77
58	47	06	327	06	82
59	43	8.509 4295	356	05	87
60	8.508 6440	8.509 4283	1.62384	2.3403	6.5792

LATITUDE 59°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.19	log **C** diff. 1″ = +0.48	log **D** diff. 1″ = −0.02	log **E** diff. 1″ = +0.09
° ′					
59 00	8.508 6440	8.509 4283	1.62384	2.3403	6.5792
1	36	72	413	02	97
2	32	61	441	01	6.5802
3	28	49	470	2.3399	07
4	24	38	498	98	13
05	21	26	527	97	18
6	17	15	555	95	23
7	13	04	584	94	28
8	09	8.509 4192	612	92	33
9	05	81	641	91	38
10	8.508 6402	8.509 4170	1.62669	2.3390	6.5843
11	8.508 6398	58	698	88	48
12	94	47	727	87	54
13	90	36	755	86	59
14	87	24	784	84	64
15	83	8.509 4113	812	83	69
16	79	02	841	82	74
17	75	8.509 4090	870	80	79
18	71	79	898	79	84
19	68	68	927	78	89
20	8.508 6364	8.509 4056	1.62955	2.3376	6.5895
21	60	45	984	75	6.5900
22	56	34	1.63013	73	05
23	53	22	041	72	10
24	49	11	070	71	15
25	45	8.509 4000	099	69	20
26	41	8.509 3989	127	68	26
27	38	77	156	67	31
28	34	66	185	65	36
29	30	55	214	64	41
30	8.508 6326	8.509 3943	1.63242	2.3362	6.5946
31	23	32	271	61	51
32	19	21	300	60	57
33	15	10	329	58	62
34	11	8.509 3898	357	57	67
35	08	87	386	55	72
36	04	76	415	54	77
37	00	65	444	53	82
38	8.508 6296	53	473	51	88
39	93	42	501	50	93
40	8.508 6289	8.509 3831	1.63530	2.3348	6.5998
41	85	20	559	47	6.6003
42	81	08	588	46	08
43	78	8.509 3797	617	44	14
44	74	86	646	43	19
45	70	75	674	41	24
46	66	63	703	40	29
47	63	52	732	38	34
48	59	41	761	37	40
49	55	30	790	36	45
50	8.508 6251	8.509 3719	1.63819	2.3334	6.6050
51	48	08	848	33	55
52	44	8.509 3696	877	31	61
53	40	85	906	30	66
54	36	74	935	28	71
55	33	63	964	27	76
56	29	52	993	26	81
57	25	40	1.64022	24	87
58	22	29	051	23	92
59	18	18	080	21	97
60	8.508 6214	8.509 3607	1.64109	2.3320	6.6102

LATITUDE **60°**

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.18	log **C** diff. 1″ = +0.49	log **D** diff. 1″ = −0.03	log **E** diff. 1″ = +0.09
° ′					
60 0	8.508 6214	8.509 3607	1.64109	2.3320	6.6102
1	10	8.509 3596	138	18	08
2	07	85	167	17	13
3	03	73	196	16	18
4	8.508 6199	62	225	14	23
05	96	51	254	13	29
6	92	40	283	11	34
7	88	29	312	10	39
8	84	18	341	08	44
9	81	07	370	07	50
10	8.508 6177	8.509 3495	1.64400	2.3305	6.6155
11	73	84	429	04	60
12	70	73	458	02	66
13	66	62	487	01	71
14	62	51	516	2.3299	76
15	58	40	545	98	81
16	55	29	574	96	87
17	51	18	604	95	92
18	47	07	633	93	97
19	44	8.509 3395	662	92	6.6203
20	8.508 6140	8.509 3384	1.64691	2.3291	6.6208
21	36	73	720	89	13
22	33	62	750	88	18
23	29	51	779	86	24
24	25	40	808	85	29
25	21	29	838	83	34
26	18	18	867	82	40
27	14	07	896	80	45
28	10	8.509 3296	925	79	50
29	07	85	955	77	56
30	8.508 6103	8.509 3274	1.64984	2.3276	6.6261
31	8.508 6099	63	1.65013	74	66
32	96	52	043	73	72
33	92	40	072	71	77
34	88	29	101	69	82
35	85	18	131	68	87
36	81	07	160	66	93
37	77	8.509 3196	190	65	98
38	74	85	219	63	6.6304
39	70	74	248	62	09
40	8.508 6066	8.509 3163	1.65278	2.3260	6.6314
41	63	52	307	59	20
42	59	41	337	57	25
43	55	30	366	56	30
44	52	19	396	54	36
45	48	8.509 3108	425	53	41
46	44	8.509 3097	455	51	46
47	41	86	484	50	52
48	37	75	514	48	57
49	33	64	543	47	62
50	8.508 6030	8.509 3053	1.65573	2.3245	6.6368
51	26	42	602	43	73
52	22	31	632	42	79
53	19	20	661	40	84
54	15	10	691	39	89
55	11	8.509 2999	721	37	95
56	08	88	750	36	6.6400
57	04	77	780	34	05
58	00	66	809	33	11
59	8.508 5997	55	839	31	16
60	8.508 5993	8.509 2944	1.65869	2.3229	6.6422

LATITUDE 61°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.18	log **C** diff. 1″ = +0.50	log **D** diff. 1″ = −0.03	log **E** diff. 1″ = +0.09
° ′					
61 00	8.508 5993	8.509 2944	1.65869	2.3229	6.6422
1	89	33	898	28	27
2	86	22	928	26	32
3	82	11	958	25	38
4	79	00	987	23	43
05	75	8.509 2889	1.66017	22	48
6	71	78	047	20	54
7	68	67	076	18	59
8	64	56	106	17	65
9	60	46	136	15	70
10	8.508 5957	8.509 2835	1.66166	2.3214	6.6476
11	53	24	195	12	81
12	49	13	225	10	87
13	46	02	255	09	92
14	42	8.509 2791	285	07	97
15	39	80	315	06	6.6503
16	35	69	344	04	08
17	31	58	374	02	14
18	28	48	404	01	19
19	24	37	434	2.3199	25
20	8.508 5920	8.509 2726	1.66464	2.3198	6.6530
21	17	15	494	96	36
22	13	04	524	94	41
23	10	8.509 2693	553	93	46
24	06	83	583	91	52
25	02	72	613	90	57
26	8.508 5899	61	643	88	63
27	95	50	673	86	68
28	92	39	703	85	74
29	88	28	733	83	79
30	8.508 5884	8.509 2618	1.66763	2.3181	6.6585
31	81	07	793	80	90
32	77	8.509 2596	823	78	96
33	74	85	853	77	6.6601
34	70	74	883	75	07
35	66	64	913	73	12
36	63	53	943	72	18
37	59	42	973	70	23
38	56	31	1.67003	68	29
39	52	20	033	67	34
40	8.508 5848	8.509 2510	1.67063	2.3165	6.6640
41	45	8.509 2499	094	63	45
42	41	88	124	62	51
43	38	77	154	60	56
44	34	67	184	58	62
45	30	56	214	57	67
46	27	45	244	55	73
47	23	34	274	53	78
48	20	24	305	52	84
49	16	13	335	50	89
50	8.508 5813	8.509 2402	1.67365	2.3148	6.6695
51	09	8.509 2391	395	47	6.6700
52	05	81	425	45	06
53	02	70	456	43	12
54	8.508 5798	59	486	41	17
55	95	49	516	40	23
56	91	38	547	38	28
57	88	27	577	37	34
58	84	16	607	35	39
59	80	06	637	33	45
60	8.508 5777	8.509 2295	1.67668	2.3132	6.6750

LATITUDE 62°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.18	log **C** diff. 1″ = +0.51	log **D** diff. 1″ = −0.03	log **E** diff. 1″ = +0.09
° ′					
62 00	8. 508 5777	8. 509 2295	1. 67668	2. 3132	6. 6750
1	73	84	698	30	56
2	70	74	728	28	61
3	66	63	759	27	67
4	63	52	789	25	73
05	59	42	820	23	78
6	55	31	850	21	84
7	52	20	880	20	89
8	48	10	911	18	95
9	45	8. 509 2199	941	16	6. 6801
10	8. 508 5741	8. 509 2188	1. 67972	2. 3115	6. 6806
11	38	78	1. 68002	13	12
12	34	67	033	11	17
13	30	56	063	09	23
14	27	46	094	08	29
15	24	35	124	06	34
16	20	25	155	04	40
17	16	14	185	03	45
18	13	03	216	01	51
19	09	8. 509 2093	246	2. 3099	57
20	8. 508 5706	8. 509 2082	1. 68277	2. 3097	6. 6862
21	02	71	307	96	68
22	8. 508 5699	61	338	94	73
23	95	50	369	92	79
24	92	40	399	90	85
25	88	29	430	88	90
26	85	19	461	87	96
27	81	08	491	85	6. 6902
28	77	8. 509 1997	522	83	07
29	74	87	553	82	13
30	8. 508 5671	8. 509 1976	1. 68583	2. 3080	6. 6919
31	67	66	614	78	24
32	64	55	645	76	30
33	60	45	675	75	36
34	56	34	706	73	41
35	53	23	737	71	47
36	49	13	768	69	53
37	46	02	799	67	58
38	42	8. 509 1892	829	66	64
39	39	81	860	64	70
40	8. 508 5635	8. 509 1871	1. 68891	2. 3062	6. 6975
41	32	60	922	60	81
42	28	50	953	59	87
43	25	39	984	57	92
44	21	29	1. 69014	55	98
45	18	18	045	53	6. 7004
46	14	08	076	51	09
47	11	8. 509 1797	107	50	15
48	07	87	138	48	21
49	04	76	169	46	26
50	8. 508 5600	8. 509 1766	1. 69200	2. 3044	6. 7032
51	8. 508 5597	55	231	42	38
52	93	45	262	41	44
53	90	34	293	39	49
54	86	24	324	37	55
55	83	14	355	35	61
56	80	03	386	33	67
57	76	8. 509 1693	417	32	72
58	73	82	448	30	78
59	69	72	479	28	84
60	8. 508 5566	8. 509 1661	1. 69510	2. 3026	6. 7089

LATITUDE 63°

Lat.	log A diff. 1″ = −0.06	log B diff. 1″ = −0.17	log C diff. 1″ = +0.52	log D diff. 1″ = −0.03	log E diff. 1″ = +0.10
° ′					
63 00	8.508 5566	8.509 1661	1.69510	2.3026	6.7089
1	62	51	541	24	95
2	59	40	572	22	6.7101
3	55	30	603	21	07
4	52	20	635	19	12
05	48	09	666	17	18
6	45	8.509 1599	697	15	24
7	41	88	728	13	30
8	38	78	759	11	35
9	34	68	791	10	41
10	8.508 5531	8.509 1557	1.69822	2.3008	6.7147
11	27	47	853	06	53
12	24	36	884	04	59
13	20	26	915	02	64
14	17	16	947	00	70
15	14	05	978	2.2998	76
16	10	8.509 1495	1.70009	97	82
17	07	85	041	95	88
18	03	74	072	93	93
19	00	64	103	91	99
20	8.508 5496	8.509 1454	1.70135	2.2989	6.7205
21	93	43	166	87	11
22	89	33	197	85	17
23	86	23	229	83	22
24	83	12	260	82	28
25	79	02	292	80	34
26	76	8.509 1392	323	78	40
27	72	81	355	76	46
28	69	71	386	74	51
29	65	61	417	72	57
30	8.508 5462	8.509 1350	1.70449	2.2970	6.7263
31	58	40	480	68	69
32	55	30	512	66	75
33	52	19	544	65	81
34	48	09	575	63	86
35	45	8.509 1299	607	61	92
36	41	89	638	59	98
37	38	78	670	57	6.7304
38	34	68	701	55	10
39	31	58	733	53	16
40	8.508 5428	8.509 1248	1.70765	2.2951	6.7322
41	24	37	796	49	28
42	21	27	828	47	33
43	17	17	860	45	39
44	14	07	891	44	45
45	11	8.509 1196	923	42	51
46	07	86	955	40	57
47	04	76	986	38	63
48	00	66	1.71018	36	69
49	8.508 5397	55	050	34	75
50	8.508 5394	8.509 1145	1.71082	2.2932	6.7381
51	90	35	114	30	86
52	87	25	145	28	92
53	83	15	177	26	98
54	80	04	209	24	6.7404
55	77	8.509 1094	241	22	10
56	73	84	273	20	16
57	70	74	305	18	22
58	66	64	337	16	28
59	63	54	368	14	34
60	8.508 5360	8.509 1043	1.71400	2.2912	6.7440

LATITUDE 64°

Lat.	log **A** diff. 1″ = −0.06	log **B** diff. 1″ = −0.17	log **C** diff. 1″ = +0.54	log **D** diff. 1″ = −0.03	log **E** diff. 1″ = +0.10
° ′					
64 00	8.508 5360	8.509 1043	1.71400	2.2912	6.7440
1	56	33	432	10	46
2	53	23	464	08	52
3	49	13	496	07	58
4	46	03	528	05	63
05	43	8.509 0993	560	03	69
6	39	82	592	01	75
7	36	72	624	2.2899	81
8	33	62	656	97	87
9	29	52	688	95	93
10	8.508 5326	8.509 0942	1.71720	2.2893	6.7499
11	22	32	752	91	6.7505
12	19	22	785	89	11
13	16	12	817	87	17
14	12	02	849	85	23
15	09	8.509 0891	881	83	29
16	06	81	913	81	35
17	02	71	945	79	41
18	8.508 5299	61	977	77	47
19	96	51	1.72010	75	53
20	8.508 5292	8.509 0841	1.72042	2.2873	6.7559
21	89	31	074	71	65
22	85	21	106	69	71
23	82	11	139	67	77
24	79	01	171	65	83
25	75	8.509 0791	203	63	89
26	72	81	235	61	95
27	69	71	268	59	6.7601
28	65	61	300	56	07
29	62	51	332	54	13
30	8.508 5259	8.509 0741	1.72365	2.2852	6.7619
31	55	31	397	50	25
32	52	21	430	48	31
33	49	11	462	46	37
34	45	01	495	44	43
35	42	8.509 0691	527	42	49
36	39	81	559	40	56
37	35	71	592	38	62
38	32	61	624	36	68
39	29	51	657	34	74
40	8.508 5225	8.509 0641	1.72689	2.2832	6.7680
41	22	31	722	30	86
42	19	21	755	28	92
43	15	11	787	26	98
44	12	01	820	24	6.7704
45	09	8.509 0591	852	22	10
46	05	81	885	20	16
47	02	71	918	17	22
48	8.508 5199	61	950	15	28
49	95	51	983	13	35
50	8.508 5192	8.509 0541	1.73016	2.2811	6.7741
51	89	31	048	09	47
52	86	21	081	07	53
53	82	11	114	05	59
54	79	01	146	03	65
55	76	8.509 0491	179	01	71
56	72	82	212	2.2799	77
57	69	72	245	97	84
58	66	62	278	94	90
59	62	52	310	92	96
60	8.508 5159	8.509 0442	1.73343	2.2790	6.7802

TABLE OF CORRECTIONS TO LONGITUDE FOR DIFFERENCE IN ARC AND SINE.

Log K (−)	Log difference.	Log d M (+)	Log K (−)	Log difference.	Log d M (+)	Log K (−)	Log difference.	Log d M (+)
3.876	0.000 0001	2.385	4.813	0.000 0075	3.322	5.114	0.000 0300	3.623
4.026	02	2.535	4.825	080	3.334	5.120	309	3.629
4.114	03	2.623	4.834	084	3.343	5.126	318	3.635
4.177	04	2.686	4.849	089	3.358	5.132	327	3.641
4.225	05	2.734	4.860	094	3.369	5.138	336	3.647
4.265	06	2.774	4.871	098	3.380	5.144	345	3.653
4.298	07	2.807	4.882	103	3.391	5.150	354	3.659
4.327	08	2.836	4.892	108	3.401	5.156	364	3.665
4.353	09	2.862	4.903	114	3.412	5.161	373	3.670
4.376	10	2.885	4.913	119	3.422	5.167	383	3.676
4.396	11	2.905	4.922	124	3.431	5.172	392	3.681
4.415	12	2.924	4.932	130	3.441	5.178	402	3.687
4.433	13	2.942	4.941	136	3.450	5.183	412	3.692
4.449	14	2.958	4.950	142	3.459	5.188	422	3.697
4.464	15	2.973	4.959	147	3.468	5.193	433	3.702
4.478	16	2.987	4.968	153	3.477	5.199	443	3.708
4.491	17	3.000	4.976	160	3.485	5.204	453	3.713
4.503	18	3.012	4.985	166	3.494	5.209	464	3.718
4.526	20	3.035	4.993	172	3.502	5.214	474	3.723
4.548	23	3.057	5.002	179	3.511	5.219	486	3.728
4.570	25	3.079	5.010	186	3.519	5.223	497	3.732
4.591	27	3.100	5.017	192	3.526	5.228	508	3.737
4.612	30	3.121	5.025	199	3.534	5.233	519	3.742
4.631	33	3.140	5.033	206	3.542	5.238	530	3.747
4.649	36	3.158	5.040	213	3.549	5.242	541	3.751
4.667	39	3.176	5.047	221	3.556	5.247	553	3.756
4.684	42	3.193	5.054	228	3.563	5.251	565	3.760
4.701	45	3.210	5.062	236	3.571	5.256	577	3.765
4.716	48	3.225	5.068	243	3.577	5.260	588	3.769
4.732	52	3.241	5.075	251	3.584	5.265	600	3.774
4.746	56	3.255	5.082	259	3.591	5.269	613	3.778
4.761	59	3.270	5.088	267	3.597	5.273	625	3.782
4.774	63	3.283	5.095	275	3.604	5.278	637	3.787
4.788	67	3.297	5.102	284	3.611	5.282	650	3.791
4.801	71	3.310	5.108	292	3.617	5.286	663	3.795

TABLE OF VALUES OF LOG $\frac{1}{\cos \frac{1}{2} d L}$

$d L$	$\log \frac{1}{\cos \frac{1}{2} d L}$	$d L$	$\log \frac{1}{\cos \frac{1}{2} d L}$	$d L$	$\log \frac{1}{\cos \frac{1}{2} d L}$	$d L$	$\log \frac{1}{\cos \frac{1}{2} d L}$	$d L$	$\log \frac{1}{\cos \frac{1}{2} d L}$
′		′		′		′		′	
10	0.000 000	28	0.000 004	46	0.000 010	64	0.000 019	82	0.000 031
11	1	29	4	47	10	65	19	83	32
12	1	30	4	48	11	66	20	84	32
13	1	31	4	49	11	67	21	85	33
14	1	32	5	50	11	68	21	86	34
15	1	33	5	51	12	69	22	87	35
16	1	34	5	52	12	70	22	88	36
17	1	35	6	53	13	71	23	89	36
18	1	36	6	54	13	72	24	90	37
19	2	37	6	55	14	73	24	91	38
20	2	38	7	56	14	74	25	92	39
21	2	39	7	57	15	75	26	93	40
22	2	40	7	58	15	76	26	94	41
23	2	41	8	59	16	77	27	95	41
24	3	42	8	60	16	78	28	96	42
25	3	43	8	61	17	79	29	97	43
26	3	44	9	62	18	80	29	98	44
27	3	45	9	63	18	81	30	99	45

TABLE OF LOG **F**.

Lat.	Log **F**	Lat.	Log **F**	Lat.	Log **F**	Lat.	Log
°		°		°		°	
23	7.812	34	7.877	45	7.840	56	7.706
24	23	35	77	46	32	57	7.688
25	32	36	77	47	24	58	69
26	41	37	76	48	14	59	49
27	49	38	74	49	04	60	27
28	55	39	72	50	7.792	61	05
29	61	40	69	51	80	62	7.581
30	66	41	64	52	67	63	56
31	70	42	60	53	53	64	29
32	73	43	54	54	38	65	01
33	75	44	48	55	23	66	7.471

FORMULA AND TABLE FOR COMPUTING THE SPHERICAL EXCESS OF TRIANGLES.

In every spherical triangle the excess of the sum of the three angles over 180° bears the same ratio to eight right angles as the area of the triangle bears to that of the whole sphere. Putting r for radius, ε for the excess, we have $\frac{\varepsilon}{4\,\pi} = \frac{area}{4\,r^2\,\pi}$, hence $\varepsilon = \frac{area}{r^2}$. In order to express ε in seconds of arc, we must divide the expression by sin 1″. The area of the triangle, when it is small in relation to the whole sphere, as is the case in all geodetic triangles, may be expressed with sufficient accuracy for this purpose by $\frac{1}{2}$ A B sin c, where A and B are two sides and c the included angle. We have then

$$\varepsilon = \frac{\mathrm{A\,B}\sin c}{2\,r^2 \sin 1''}$$

In estimating ε in a triangle on the terrestrial spheroid, we can refer it to an osculating sphere, the radius of which is taken as the mean of the radii of curvature in the meridian and prime vertical at the center of the triangle. These are respectively

$$\mathrm{R} = \frac{a\,(1 - e^2)}{(1 - e^2 \sin^2 \mathrm{L})^{\frac{3}{2}}} \qquad \mathrm{N} = \frac{a}{(1 - e^2 \sin^2 \mathrm{L})^{\frac{1}{2}}}$$

using the notation of the L, M, Z formulæ.

The mean of these two expressions developed, but embracing only terms below the fourth power of e, is

$$\tfrac{1}{2}\,(\mathrm{R} + \mathrm{N}) = a\,(1 - \tfrac{1}{2}\,e^2 \cos 2\,\mathrm{L} + \ldots)$$

We have, therefore, for the spheroidal triangle,

$$\varepsilon = \frac{\mathrm{A\,B}\sin c}{2\,a^2\,(1 - \frac{1}{2}\,e^2 \cos 2\,\mathrm{L})^2 \sin 1''}$$

for which we write $\varepsilon = \mathrm{A\,B}\sin c \times m$, and tabulate the logarithms of $m = \frac{1}{2\,a^2\,(1 - \frac{1}{2}\,e^2 \cos 2\,\mathrm{L})^2 \sin 1''}$ for different latitudes.

TABLE OF LOG m.

Latitude.	Log m.	Latitude.	Log m.	Latitude.	Log m.	Latitude.	Log m.
° ′		° ′		° ′		° ′	
20 00	1.40625	32 00	1.40528	44 00	1.40410	56 00	1.40290
20 30	622	32 30	524	44 30	405	56 30	285
21 00	619	33 00	519	45 00	400	57 00	280
21 30	615	33 30	514	45 30	395	57 30	276
22 00	612	34 00	509	46 00	390	58 00	271
22 30	608	34 30	505	46 30	385	58 30	266
23 00	604	35 00	500	47 00	380	59 00	262
23 30	601	35 30	495	47 30	375	59 30	257
24 00	597	36 00	491	48 00	369	60 00	253
24 30	592	36 30	486	48 30	364	60 30	249
25 00	588	37 00	481	49 00	359	61 00	244
25 30	584	37 30	476	49 30	354	61 30	240
26 00	580	38 00	471	50 00	349	62 00	236
26 30	576	38 30	466	50 30	344	62 30	231
27 00	572	39 00	461	51 00	339	63 00	227
27 30	568	39 30	456	51 30	334	63 30	223
28 00	564	40 00	451	52 00	329	64 00	219
28 30	559	40 30	446	52 30	324	64 30	215
29 00	555	41 00	441	53 00	319	65 00	211
29 30	551	41 30	436	53 30	314	65 30	207
30 00	547	42 00	431	54 00	309	66 00	203
30 30	542	42 30	426	54 30	304	66 30	200
31 00	537	43 00	420	55 00	299	67 00	196
31 30	1.40533	43 30	1.40415	55 30	1.40295	67 30	1.40192

The above table is computed for the Clarke spheroid of 1866.

Appendix No. 8.

THE RUN OF THE MICROMETER.

By GEORGE DAVIDSON, Assistant.

COAST AND GEODETIC SURVEY OFFICE,
Washington, January 15, 1885.

DEAR SIR: I herewith transmit the paper upon "The Run of the Micrometer," which you asked for a short time since in response to my mention that it had been of such use to the younger members of my party and to others that this fact seemed to warrant its publication among the appendices of your report.

Yours, respectfully,

GEORGE DAVIDSON,
Assistant.

Prof. J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

THE RUN OF THE MICROMETER.

The term "run of the micrometer" occurs in the microscope-micrometer measurement of fractional parts of the arc between two adjacent graduations on the circle of an astronomical or geodetic instrument.

If the adjacent graduations are 5′ or 300″ apart the microscope-micrometer is so adjusted that the image of a given point on the micrometer thread in traversing the chord between the two graduations (or the tangents parallel to the chord) shall exhibit exactly 300 divisions or seconds of arc. In this case there is no run of the micrometer. But should the micrometer record more or less than the prescribed seconds of graduation, this difference is the run of the micrometer in terms of the arc value of the micrometer divisions.

In practice we find the following facts and conditions as the basis for our investigation to determine the apportionment of the run for the different fractional parts of the arc measured.

The circle is graduated to any given number of minutes of arc, usually five.

The numeration of the graduations upon the circle may increase, as the numbers on the watch face, or the reverse. The microscope-micrometer measures the arc which the zero line of the micrometer has passed over and beyond the last graduation of reference.

The micrometer screw is generally cut to make one revolution for one minute of arc, and the head of the screw is usually divided into sixty equal parts, intended to represent seconds of arc.

At each observation there are made two pointings and "readings" of each micrometer—one pointing and "reading" on the *graduation following* the micrometer line of zero, *i. e.*, on the graduation last passed by the micrometer line of zero, or fiducial line; the other pointing and "reading" on the *graduation preceding* the same micrometer line of zero, *i. e.*, on the graduation not yet reached by the micrometer line of zero.

The "*back reading*"* is the designation used for the record of the micrometer pointing on the *graduation following* the micrometer line of zero.

The "*forward reading*" is the designation used for the record of the micrometer pointing on the *graduation preceding* the micrometer line of zero.

When the micrometer is turned backwards to the last graduation passed by the zero line the numbers on the micrometer head increase. Therefore the "forward" reading subtracted from the "back" reading plus the whole revolutions, gives the number of micrometer divisions in the five-minute space.

CONDITIONS.

(*a*) If the graduations of the circle were equidistant throughout the circle;

(*b*) If the microscope-micrometer and the graduation were concentric; *i. e.*, if there were no eccentricity of the graduation;

(*c*) If the microscope-micrometer screw made exactly one revolution for one minute of arc;

(*d*) If changes of temperature did not change the distance of the microscope-micrometer from the center of rotation of the circle;

(*e*) If changes of temperature did not change the distance of the objective of the microscope from the graduated arc;

(*f*) If changes of temperature did not change the distance of the objective of the microscope from the plane of the micrometer thread;

(*g*) If the micrometer thread moved always in a plane parallel to the plane of the graduations on the circle;

(*h*) If the micrometer screw moved always at right angles to the radius denoted by the zero line of the micrometer;

(*i*) If the graduated circle did not warp from changes of temperature, or from mechanical strains in changing "position," &c.;

(*j*) If the observer made perfect pointings and readings on the graduations;

(*k*) If the micrometer line of zero remained unchanged between the "back" and "forward" readings;

(*l*) If the movement of the zero line were uniform throughout each revolution of the screw;

(*m*) If the chord or parallel tangent of a very small arc were identical with the length of the arc;

Then the part of the arc to be measured by the microscope micrometer would be determined at once by simply measuring from the line of zero to the *graduation following*, that is, measuring backwards to the graduation last passed by the line of zero, and thus reading off directly the small arc between that graduation and the line of zero.

But none of these conditions are realized in practice, and, if each of the intergraduation spaces throughout the circle has not been absolutely determined, we must assume:

(1) That the graduations throughout the circle may be equidistant, but the microscope-micrometer may be in such imperfect adjustment that one revolution of the screw does not conform to the prescribed unit of arcs (that is, the distance apart of two contiguous graduations).

(2) That, if errors of graduation exist, the graduation following and the graduation preceding the micrometer line of zero are equally displaced, and in contrary directions.

(3) That the changes in the distance of the objective of the microscope-micrometer from the plane of the graduated circle; changes in the distance of the plane of the micrometer thread from the objective of the microscope; changes in the parallelism of the planes of the micrometer thread and the graduated circle; changes in the distance of the axis of the micrometer screw from the center of rotation of the circle, &c., all displace the images of the forward and back graduated lines equally and in opposite directions.

(4) That, if the perpendicularity of the microscope-micrometer to the plane of the graduated

* For the use of the terms "back" and "forward" readings, consult Albrecht, "Formeln und Hülfstafeln für geographische Orts-Bestimmungen," &c. (p. 49), Leipsic, 1873.

Also Zacharie, "Die geodätischen Hauptpunkte und ihre Co-Ordinaten" (p. 73), Berlin, 1878.

arc has been disturbed in the vertical plane of the instrument passing through the center of rotation and the zero line of the micrometer, the images of the forward and back graduations are equally displaced and in opposite directions.

(5) That, if the line of zero has changed in azimuth, the forward and back readings are equally affected and in opposite directions.

(6) These changes are supposed to take place between the readings of the back and forward graduations.

(7) That in the pointing on each graduation the observer makes equal errors which have the same sign or which have opposite signs.

It is evident that these assumptions are similar in character, and that in consequence of the existence of any or all of them, one revolution of the micrometer screw moves the zero thread through an arc (rigorously along the chord of a very small arc, or along the tangents parallel thereto) not of the constant value of $60''$ but of $60'' + r$. This quantity r exhibits itself as the difference between the back and forward readings of the micrometer, and is the "run" of the microscope-micrometer. And it is also evident that the proper point from which to measure the micrometer part of the arc is the middle point between each two consecutive graduations.

In order, therefore, to obtain the most probable value of the fractional arc measured by the microscope-micrometer, when the readings of the pointings upon the two adjacent graduations differ, it is necessary to determine a correction to each reading, or to either or to the mean of the two readings based upon the preceding considerations:

For this investigation let us make:

D = the mean value in micrometer divisions of the space between every two consecutive graduations of the whole circle.

b = the position of the zero line of the micrometer referred to the graduation last passed, in micrometer divisions; and denominated the "back" reading of the micrometer.

If the zero line is between the graduation last passed and the middle point of the two graduations, the "forward" reading is referred to the "back" reading by means of D.

And (supposing three equally or nearly equidistant microscopes) in the reductions, $b = \frac{A+B+C}{3}$ where the three "back" readings of the microscope-micrometers are A, B, and C.

f = the position of the zero line of the micrometer referred from the graduation not yet reached by it, and denominated the "forward" reading of the micrometer. If the zero line is between the middle point of the two graduations, and the graduation not yet reached, the "back" reading is referred to the forward reading by means of D. And in the reductions $f = \frac{A' + B' + C'}{3}$, where the three "forward" readings of the microscope-micrometers are A′, B′, and C′.

$\triangle = (300 + b) - f$ = the observed number of micrometer divisions between the two given graduations; and always very nearly equal to D.

$d = \triangle - D$.

$m = \frac{1}{2}(b + f)$ = the observed position of the zero line of the micrometer, as referred to two actual graduations.

M = The corrected position of the zero line of the micrometer as referred to two mean graduations, taking the place of the two actual graduations.

If the "forward" and the "back" readings of the micrometer pointings are identical (that is, if $b = f$), then $\triangle = D$, and no correction is required to either reading, nor to the mean of both; and the position of the zero line of the micrometer is given directly by b, or by f, or by m, which is equal to M in this case. But if the forward and back readings differ, then a correction is necessary to each reading, b and f, or to either of them, or to m, the mean of both.

And it is evident that, in application, the quantity $\triangle - D$ must be apportioned to the two discordant micrometer readings; that is, to the two observed discordant positions of the zero line.

This correction, as already defined, is the "run of the micrometer," and is represented by r.

[It is evident that $\frac{(\triangle - D)}{n}$, where n is the number of measures of $\triangle$, is the *mean run* of the

microscope-micrometer so long as there is no change of the conditions in the relation of the micrometer to the arc measured. This mean run is designated by ρ.]

The correction r is thus examined: When the space ($\triangle$) between two consecutive graduations is measured *greater* than the mean number of micrometer divisions (D) between every two graduations, the distance of the zero line from the graduation last passed will be given *too great* by the "back" reading b alone; and the distance of the zero line from the graduation not yet reached, as derived through the "forward" reading f reduced by means of D, will be given *too small* by the forward reading f alone.

The "back" reading b must therefore be numerically decreased by a quantity depending *directly* upon the distance of the zero line from the graduation last passed, diminished by $\frac{1}{2}d$, and multiplied by d; and *inversely* as the value of $\triangle$. But as D is very nearly equal to $\triangle$, we may, without sensible error, use D for $\triangle$ in this case; and then the correction to b is

$$c = \frac{(b - \frac{1}{2}d)\,d}{\mathrm{D}}$$

And the forward reading f must therefore be numerically increased by a quantity depending *directly* upon the distance of the zero line from the graduation not yet reached (as derived through the forward reading and D), diminished by $\frac{1}{2}d$, and multiplied by d; and *inversely* as the value of $\triangle$.

As before, we use D for $\triangle$, and then the correction to f is

$$c' = \frac{[(\mathrm{D} - \frac{1}{2}d) - f]d}{\mathrm{D}}$$

When the space between the two consecutive graduations ($\triangle$) is measured *less* than the mean number of micrometer divisions between every two graduations (D) it is evident that the distance of the zero line as derived from the graduation last passed will be given *too small* by the "back" reading b alone; and that the distance of the zero line from the graduation not yet reached, as derived from the "forward" reading f, and reduced through means of D, will be given *too great* by the forward reading f alone.

These readings must therefore be corrected in a manner similar to the preceding.

But instead of correcting each reading separately, it is preferable to apply one correction directly to the mean m.

As $m = \frac{b+f}{2}$ the correction thereto is

$$\frac{c+c'}{2} = \frac{d\,[(\mathrm{D}-\frac{1}{2}d)-f] - (b-\frac{1}{2}d)\,d}{2\,\mathrm{D}} = \frac{d(\mathrm{D}-\frac{1}{2}d) - d[f + (b - \frac{1}{2}d)]}{2\,\mathrm{D}} = \frac{d\,\mathrm{D} - \frac{1}{2}d^2 - d(f+b) + \frac{1}{2}d^2}{2\,\mathrm{D}}$$

$$= \frac{d}{2} - \frac{m.d}{\mathrm{D}}$$

whence

$$\mathrm{M} = m + \frac{d}{2} - \frac{m.d}{\mathrm{D}}$$

The correction $\left(\frac{d}{2} - \frac{m.d}{\mathrm{D}}\right)$ is designated the actual run of the micrometer and is represented by r. A table of double entry may be calculated from this formula, using as arguments the distance, in seconds, of the zero line from the graduation last passed b, and the value of d, for tenths of seconds, from 0 to 3″.0. It is only necessary to compute the correction so far as $\frac{1}{2}$ D, because at that point it simply changes the sign, and numerically increases to D.*

Calling $\mathrm{D} = 300''$, the correction may be put in the form

$$r = \mathrm{M} - m = -\left(\frac{m}{300} - \frac{1}{2}\right)d$$

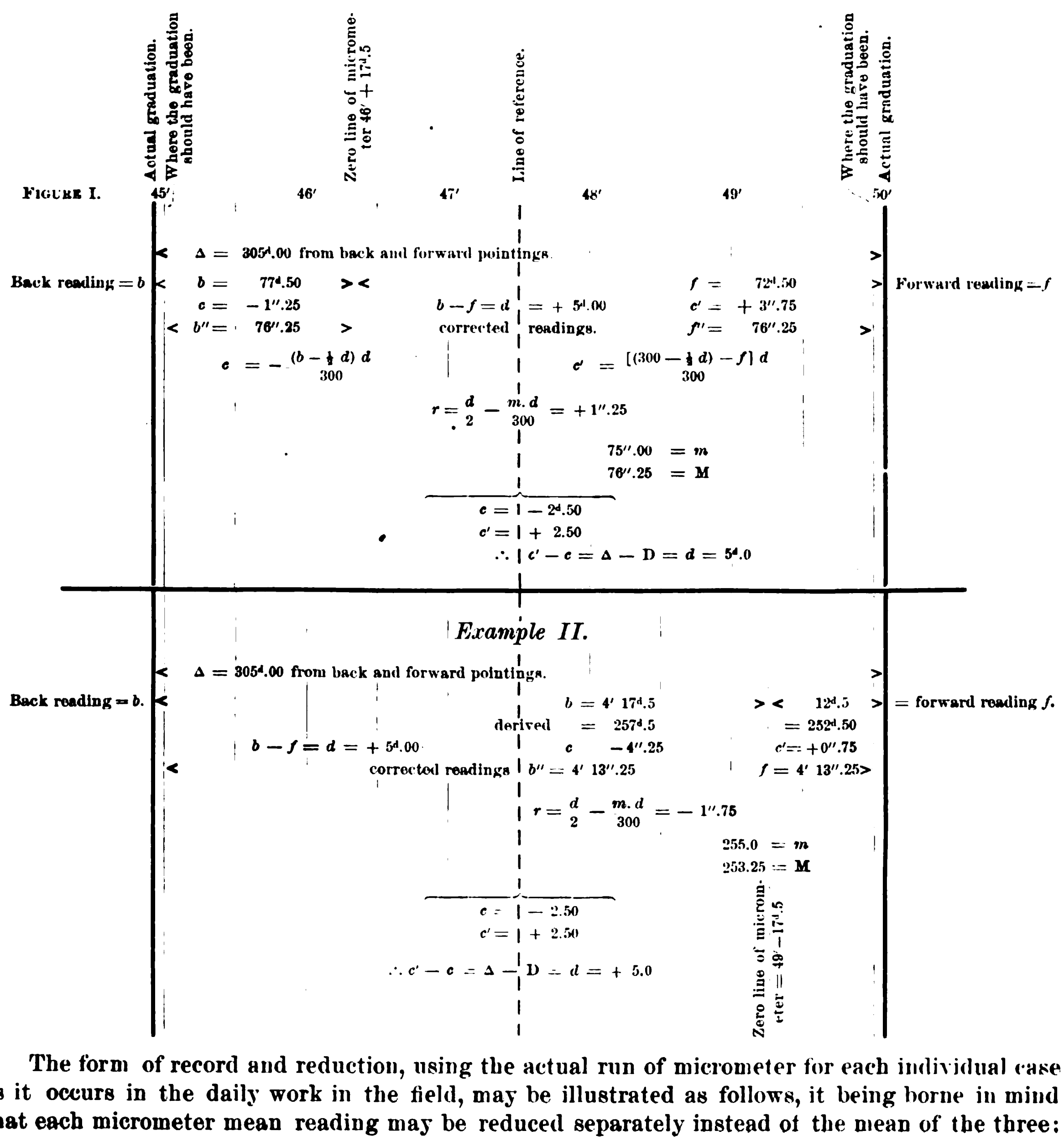
*See annexed Table of corrections for Run of Microscope-Micrometers: $\mathrm{D} = 300'$.

It is here proposed, Fig. I, to give a graphical illustration of the graduation and corrections of a 5′ space, which is in reality larger than that quantity. The actual graduations, 45′ and 50′, are represented by heavy lines; the positions where these lines should be are represented by fine lines quite close to the former. The distance apart of these fine lines is 300″ (= D); the measured distance apart of the two actual graduations is 305 micrometer divisions (= △), which may be assumed without sensible error as 305 seconds of arc. Other fine lines have been introduced to indicate the other minutes 46, 47, 48, 49 and the half minutes. The line of reference midway between the two graduations is denoted by a dashed line, and the zero line of the micrometer, or the fiducial line, by a dotted line.

In the first example, the micrometer line of zero has passed the last graduation (45′), by 77.5 micrometer divisions, but is not up to the line of reference; in the second example, the micrometer line of zero has passed 257.5 micrometer divisions beyond the 45′ graduation and is necessarily beyond the line of reference.

Example I.

FIGURE I.



The form of record and reduction, using the actual run of micrometer for each individual case as it occurs in the daily work in the field, may be illustrated as follows, it being borne in mind hat each micrometer mean reading may be reduced separately instead of the mean of the three:

Examples.

Mic.	° ′	Forward reading f.	Back reading b.	Mean $\frac{f+b}{2}$	$\frac{d}{2}-\frac{m.d}{300}$	Corrected reading.
		Example I.				
	° ′	*Divs.*	*Divs.*	*Divs.*	*Divs.*	″
A	7 46	12.5	17.5			
B		19.3	23.7			
C		16.8	20.0			
		16.20	20.40	18.30	+1.00	19.30
		Example II.				
A	7 49	12.5	17.5			
B		16.8	20.0			
C		19.3	23.7			
		16.20	20.40	18.30	−1.52	16.78

Having determined the *mean run* of the microscope-micrometers at a station, when no change of conditions has interposed, it is required to furnish a table of *run corrections*, which shall change by regular numerical increments of 0″.01, and for which the arguments shall be m and r.

Make b = the "back" reading of the microscope-micrometer, the mean of the three.
b' = any other back reading.
f = the forward reading of the microscope-micrometer.
f' = any other forward reading.
&c., &c.

Then

$$m=\frac{b+f}{2} \qquad m'=\frac{b'+f'}{2}, \text{ \&c.}$$

Call ρ = the *mean run* over all the 5′ spaces read at △.
r = the *correction* for *run* for m.
r' = the *correction* for *run* for m'.

Then

$$r=\pm\left(\frac{m}{300}-\tfrac{1}{2}\right)\rho \qquad \therefore m=300\left(\frac{2r+\rho}{2\rho}\right)$$

$$r'=\pm\left(\frac{m'}{300}-\tfrac{1}{2}\right)\rho \qquad \therefore m'=300\left(\frac{2r'+\rho}{2\rho}\right)$$

&c., &c., &c.

$$m-m'=\frac{300\,(2r+\rho)}{2\rho}-300\,\frac{(2r'+\rho)}{2\rho}=300\,\frac{r-r'}{\rho}$$

Then if we require $r-r'=0.''01$ we have

$$m-m'=\frac{3''}{\rho}$$

And if the minus sign is used in the values of r and r', the $r-r'$ becomes $r'-r$.

The value of r for $m=2'\,30''$ is of course 0″.00; and from 2′ 30″ to 0′ 00″, and from 2′ 30″ to 5′ 00″, the numerical values increase 0″.01 for each value of $m-m'$ with different signs.

The following examples exhibit the necessary tables for two stations. There were three conditions of the microscope-micrometers at △ Northwest Yolo Base Line. The one with the exceptionally large run is given.

[Where this refinement to 0″.01 is not warranted by the conditions of the instrument, &c., the correction is taken to the nearest 0″.1 only and the tabulation is usually made for an assumed run of 1″, the computer mentally multiplying the correction for any other given run.]

Example at Southeast Yolo Base Station.

From 672 observations of three microscope-micrometers each, the value of $\rho=-0''.193$ $\therefore$ $m-m'=-\frac{3''}{.193}=-15''.544$ and the table is constructed as follows:

r	m	m	r
"	′ "	′ "	"
	0 00.00	5 00.00	
+.096	02.33	4 57.67	−.096
+.09	17.88	42.12	−.09
+.08	33.42	26.58	−.08
+.07	0 48.96	4 11.04	−.07
+.06	1 04.51	3 55.49	−.06
+.05	20.05	39.95	−.05
+.04	35.50	24.41	−.04
+.03	1 51.14	3 08.86	−.03
+.02	2 06.68	2 53.32	−.02
+.01	22.23	37.77	−.01
+.00	30.00	30.00	−.00

Example at Northwest Yolo Base Station.

[From Nos. 43 to 124 $\rho=+1''.120$ $\therefore$ $m-m'=\frac{3''}{1.12}=2''.6785$.]

r	m	m	r
"	′ "	′ "	"
	0 00 00	5 00.00	
−.56	0 01.35	4 58.65	+.56
.55	04.02	55.98	.55
.54	06.70	53.30	.54
.53	09.38	50.62	.53
.52	12.06	47.94	.52
.51	14.74	45.26	.51
.50	17.42	42.58	.50
.49	20.09	39.91	.49
.48	22.77	37.23	.48
.47	25.45	34.55	.47
.46	28.13	31.87	.46
.45	30.81	29.19	.45
.44	33.49	26.51	.44
.43	36.17	23.83	.43
.42	38.84	21.16	.42
.41	41.52	18.48	.41
.40	44.20	15.80	.40
.39	46.88	13.12	.39
.38	49.56	10.44	.38
.37	52.24	07.76	.37
.36	54.92	05.08	.36
.35	0 57.60	4 02.40	.35
.34	1 00.27	3 59.73	.34
.33	02.95	57.05	.33
.32	05.63	54.37	.32
.31	08.31	51.69	.31
.30	10.99	49.01	.30
.29	13.67	46.33	.29
.28	16.34	43.66	.28
.27	19.02	40.98	.27
.26	21.70	38.30	.26
.25	24.38	35.62	.25
.24	27.06	32.94	.24
.23	29.74	30.26	.23
.22	32.42	27.58	.22
.21	35.10	24.90	.21
.20	37.77	22.23	.20
.19	40.45	19.55	.19
.18	43.13	16.87	.18
.17	45.81	14.19	.17
.16	48.49	11.51	.16
.15	51.17	08.83	.15
.14	53.84	06.15	.14
.13	56.51	03.47	.13
.12	1 59.20	3 00.80	.12
.11	2 01.88	2 58.12	.11
.10	04.56	55.44	.10
.09	07.24	52.77	.09
.08	09.91	50.09	.08
.07	12.59	47.41	.07
.06	15.27	44.73	.06
.05	17.95	42.05	.05
.04	20.62	39.38	.04
.03	23.30	36.70	.03
.02	25.98	34.02	.02
.01	28.65	31.34	.01
−.00	2 30.00	30.00	+.00

The tabulation of the *actual run*, r, of the microscope-micrometers through a series of observations at a station indicates whether any change has taken place in the value of the run from some known or unknown cause. If this change is established, the mean values of the run must be taken for the different periods when the microscope-micrometers were supposed to be under the same conditions. For example, it is evident, from an inspection of the following tabulation of the actually observed run of the microscope-micrometers (each result being the mean of three micrometers), at Station Northwest Yolo Base, that through some unexplained cause a change took place between numbers 42 and 43, and again between numbers 124 and 125; so that three values of the mean run ρ are used in the office reductions at this station.

As the run was derived from the mean of the readings of the three microscope-micrometers, A, B, and C, no clew is given by this tabulation for judging whether one micrometer or more than one was affected. It would require the tabulation of the actual run for each microscope-micrometer to establish which of them underwent change of adjustment; but the labor of reduction would be doubled and nothing essential would be gained.

Tabulation of the micrometer runs observed at Station Northwest Yolo Base. Each reading is the mean of the three microscope-micrometer readings.

f—b =+	f—b =−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	f—b +	f—b −
	.3	1.4		1.6			.6		.1		.2		.0		.5	.3			1.0		.2	.2		.8	
	.5		.6	1.4			.4		.8		.5	.9		.4			.3		1.3		.8	.2		.8	
	.9	1.1		1.8			.4	.6		.2			.4	1.0			.4		.6		.0	.4		.9	
.2		1.1		2.1			.2	1.4			.1	1.3			.1		.3		.2		.0			.1	
.6		.8		1.2			1.1		.4		.3	.9		.2			.4		.4		1.4	.3			.2
	.4	.8		1.8			.3	.2			.1	.7		.9			.6		.8		.5	.4			.6
	.6	.3			.3		.5	.4			.7	.7		.6			.6		.3		.0	.5			.6
	.7		.6	.3			.2	.1			.3	.7			.1		1.0		.0		.8	.4			.5
	.3	1.1		.3		.1		.2			.3		.1		.0		.8		.2		.4	.8		.1	
	.9	.8			.0		.7	.4		.3		.8		.1			.8	.1			.6	.2			.4
	.0	1.0			.3		.9	.9		.2		.6			.1		.2	.1			.7		.2		.2
	.4	1.0			.1		.3	.3		.3		.3		.8			.2	.6			.6	1.0			.7
	.4	1.6			.6		.3	.2			.7	.1			.2		.2	.4			.1		.0		.4
	.8	1.1		.1			.2	1.0		.5		1.4		.1			.1	.6		.4			.0		.8
	.7	1.7		.1			.5	.4			.0	.8		.1			.5		.0	1.1			.8		.2
.3		2.4			.8		.2	.3			.2	.2		.2		.3		.1			.2	.1			.6
	.6	1.1		1.2		.1		.9		1.0		.8			.5		.5		.0	.3			.4	.6	
	.7	.7			.4	1.0		.7		.1			.3		1.1		.6	.2		.7		.8			.2
	.6	1.9			.1	.1		.1			.1		.5	.1		.3		.7			.1		.8		1.0
.2		1.9			.6	1.6		.3		.9		1.0			.4		.5		.1		.4		.2		.4
	.0	1.0			.6		.2	.5			.0	.5		.8			.0		.6		.2		.7		.5
	.5	.7			.5	.3			.0	.6		.5			.8		.3		.3	.9			.4		.1
	.4	2.2			.3		.0	.6		.5		.9			1.0		.8		.2	.9			.9		.1
	.7	1.4			.3		.1		.4	.1			.0		.5		.1		.0	.2			.1		.0
.5		1.1		.6		.5			1.0		.0	.8			.1		.1	.3			.2		.9		.8
.6		2.3		.3		1.0			.2		.2	.6			.2		.1	.5			.6	.8			.5
	.4	2.0		.9			.5		.6	.1		.9		.1		.2		.1		.8			.8		.0
.8		1.6		.4			.1		.7	.9		.9			.1	.9		.2			.2	.1			.0
1.0		1.8		.3		.1			.6	.5			.7		.6	1.1			.5		.6	.8			.6
	.5	1.6		.2		1.8		.2		.4		.1			.8		.0		1.2		.5	.3			.1
	.7	2.3			.2	.2			.9	1.1			.2		.1		.0		.3	.2		.1			1.5
	.5	1.2		.1			.4		.6		.1	.5			.1	.7			1.1		.7	.4			
.4		1.5			.0	.2			.4	.8		.9			.4	.3			.8		1.0	.8			
1.2		1.4		.3		.5			.1		.1		.5	.4		1.0			.5		.7		.5		
	.4	1.4			.2		.7		.9	.6		.4			.8	1.0			1.1		.1	.6			
	.0	1.6			.3	.6			.5	.5			.7	.5			.8		.3	.3			.2		
	1.0	.3			.8		.1		1.1		.5	.2			.6	1.0		.1			.9		.3		
	.6	.5		.2			.5		.3		.9	.2		.5			.0	.1		.8			.1		
.7		2.1		.1		1.1			.4		.3	.1		.2		.7			.0	.3			.8		
.2		.8			.1		.6		.5		.9		.9		.5	.7			.5		.1	.6			
	.1	1.5			.5	.8			.5		.7	.2		.3			.9		.5		.6		.1		
1.1		1.1		.5			.7	.1			.1		.9	.7		.6			.7	.4		.1			
.2		.4			.1		.5		1.2		.6		.6	.1		.6			.2		.8		.1		
1.5			.2		.3		.9		.7		.3		.0		.5	.3			1.8		.6		.1		

Tabulation of the micrometer runs observed at station northwest Yolo Base—Continued.

$f-b$ $=+$	$f-b$ $=-$	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	$f-b$ +	$f-b$ −
.4	....	.8	....	.1	....	....	1.2	....	.2	....	.2	.3	....	.4	....	1.5	....	....	.4	.2	....	....	.0	....	....
.3	....	......	.0	.9	....	....	.2	....	.5	....	1.0	....	1.6	.3	....	....	.2	.3	....	....	.4	....	1.1	....	....
.8	....	.4	....	......	.2	.5	....	.4	....	....	.4	.3	....	....	.2	.2	....	.2	....	.1	....	....	.8	....	....
.8	....	.2	....	.2	....	....	.8	....	.2	....	.1	.4	....	.4	....	.7	....	.4	....	.2	....	....	.2	....	....
.9	....	1.2	....	......	.6	1.0	....	.7	....	....	.5	....	.4	....	.4	.7	....	.5	....	....	.3	....	.0	....	....
1.2	....	.5	....	.6	....	.3	....	.5	....	.3	....	....	.3	.6	....	....	.4	....	.1	....	.4	....	.7	....	....
1.6	....	.4	....	.3	....	....	1.3	.7	....	....	1.2	....	.5	....	.6	....	.5	....	.4	....	.4	.4	....	....	....
.6	....	1.8	....	......	.1	....	.5	.2	....	....	.9	.2	....	.6	....	.3	....	.2	....	....	.0	.7	....	....	....
1.7	....	1.3	....	.2	....	....	1.2	.1	....	....	.3	.6	....	....	.1	....	.7	.2	....	.2	....	.9	....	....	....
.4	....	.4	....	......	.6	....	.0	....	1.0	.6	....	.1	....	.3	....	....	1.2	....	.6	....	.5	....	.5	....	....
.6	....	1.9	....	......	.0	....	.4	....	.0	....	.5	.6	....	....	.7	....	1.1	....	.8	.6	....	.7	....	....	....
1.2	....	1.4	....	......	.8	....	.5	....	.8	....	.7	.9	....	....	.3	....	.3	....	.4	....	.7	1.1	....	....	....
1.6	....	1.7	....	......	.7	.1	....	....	1.1	....	.4	1.1	....	....	.2	....	.3	....	.0	.3	....	.4	....	....	....

Nos. 1 to 42 : $[f-b] = -\overset{d}{6.8} : n = 42 \therefore \rho = -\overset{''}{0.162}$

Nos. 34 to 120 : $[f-b] = +\overset{d}{87.4} : n = 78 \therefore \rho = +1.120$

Nos. 121 to 716 : $[f-b] = -\overset{d}{31.7} : n = 595 \therefore \rho = -0.053$

Table of the corrections for the "run of microscope micrometers": $D = 300''$.

[When the *mean reading m* is found at the *top* of the table, the correction to *m* is ± when $b \gtrless f$. When found at the *bottom*, the correction to *m* is ∓ when $b \gtrless f$.]

$b \sim f$.	0′												1′												2′						
	00″	05″	10″	15″	20″	25″	30″	35″	40″	45″	50″	55″	00″	05″	10″	15″	20″	25″	30″	35″	40″	45″	50″	55″	00″	05″	10″	15″	20″	25″	30″
d 0.1	.05	.05	.05	.04	.04	.04	.04	.04	.04	.04	.03	.03	.03	.03	.03	.02	.02	.02	.02	.02	.02	.01	.01	.01	.01	.01	.01	.00	.00	.00	.00
0.2	.10	.10	.09	.09	.09	.08	.08	.08	.07	.07	.07	.06	.06	.06	.05	.05	.05	.04	.04	.04	.03	.03	.03	.02	.02	.02	.01	.01	.01	.00	.00
0.3	.15	.14	.14	.13	.13	.12	.12	.11	.11	.10	.10	.09	.09	.08	.08	.07	.07	.06	.06	.05	.05	.04	.04	.03	.03	.02	.02	.01	.01	.00	.00
0.4	.20	.19	.19	.18	.17	.17	.16	.15	.15	.14	.13	.13	.12	.11	.11	.10	.09	.09	.08	.07	.07	.06	.05	.05	.04	.03	.03	.02	.01	.01	.00
0.5	.25	.24	.23	.22	.22	.21	.20	.19	.18	.18	.17	.16	.15	.14	.13	.12	.12	.11	.10	.09	.08	.07	.07	.06	.05	.04	.03	.02	.02	.01	.00
0.6	.30	.29	.28	.27	.26	.25	.24	.23	.22	.21	.20	.19	.18	.17	.16	.15	.14	.13	.12	.11	.10	.09	.08	.07	.06	.05	.04	.03	.02	.01	.00
0.7	.35	.34	.33	.32	.30	.29	.28	.27	.26	.24	.23	.22	.21	.20	.19	.17	.16	.15	.14	.13	.12	.10	.09	.08	.07	.06	.04	.03	.02	.01	.00
0.8	.40	.39	.37	.36	.35	.33	.32	.31	.29	.28	.27	.25	.24	.23	.21	.20	.19	.17	.16	.15	.13	.12	.11	.09	.08	.07	.05	.04	.03	.01	.00
0.9	.45	.44	.42	.40	.39	.38	.36	.34	.33	.32	.30	.28	.27	.25	.24	.22	.21	.19	.18	.16	.15	.13	.12	.10	.09	.07	.06	.04	.03	.02	.00
1.0	.50	.48	.47	.45	.43	.42	.40	.38	.37	.35	.33	.32	.30	.28	.27	.25	.23	.22	.20	.18	.17	.15	.13	.12	.10	.08	.07	.05	.03	.02	.00
1.1	.55	.53	.51	.50	.48	.46	.44	.42	.40	.38	.37	.35	.33	.31	.29	.27	.26	.24	.22	.20	.18	.16	.15	.13	.11	.09	.07	.05	.04	.02	.00
1.2	.60	.58	.56	.54	.52	.50	.48	.46	.44	.42	.40	.38	.36	.34	.32	.30	.28	.26	.24	.22	.20	.18	.16	.14	.12	.10	.08	.06	.04	.02	.00
1.3	.65	.63	.61	.58	.56	.54	.52	.50	.48	.45	.43	.41	.39	.37	.35	.32	.30	.28	.26	.24	.22	.19	.17	.15	.13	.11	.09	.06	.04	.02	.00
1.4	.70	.68	.65	.63	.60	.58	.56	.54	.51	.49	.47	.44	.42	.40	.37	.35	.33	.30	.28	.26	.23	.21	.19	.16	.14	.12	.09	.07	.05	.02	.00
1.5	.75	.72	.70	.67	.65	.62	.60	.57	.55	.52	.50	.47	.45	.42	.40	.37	.35	.32	.30	.27	.25	.22	.20	.17	.15	.12	.10	.07	.05	.02	.00
1.6	.80	.77	.75	.72	.69	.67	.64	.61	.59	.56	.53	.51	.48	.45	.43	.40	.37	.35	.32	.29	.27	.24	.21	.19	.16	.13	.11	.08	.05	.03	.00
1.7	.85	.82	.79	.76	.74	.71	.68	.65	.62	.59	.57	.54	.51	.48	.45	.42	.40	.37	.34	.31	.28	.25	.23	.20	.17	.14	.11	.08	.06	.03	.00
1.8	.90	.87	.84	.81	.78	.75	.72	.69	.66	.63	.60	.57	.54	.51	.48	.45	.42	.39	.36	.33	.30	.27	.24	.21	.18	.15	.12	.09	.06	.03	.00
1.9	.95	.92	.89	.85	.82	.79	.76	.73	.70	.66	.63	.60	.57	.54	.51	.47	.44	.41	.38	.35	.32	.28	.25	.22	.19	.16	.13	.09	.06	.03	.00
2.0	1.00	.97	.93	.90	.87	.83	.80	.77	.73	.70	.67	.63	.60	.57	.53	.50	.47	.43	.40	.37	.33	.30	.27	.23	.20	.17	.13	.10	.07	.03	.00
2.1	1.05	1.01	.98	.94	.91	.87	.84	.80	.77	.73	.70	.66	.63	.59	.56	.52	.49	.45	.42	.38	.35	.31	.28	.24	.21	.17	.14	.10	.07	.03	.00
2.2	1.10	1.06	1.03	.99	.95	.92	.88	.84	.81	.77	.73	.70	.66	.62	.59	.55	.51	.48	.44	.40	.37	.33	.29	.26	.22	.18	.15	.11	.07	.04	.00
2.3	1.15	1.11	1.07	1.04	1.00	.96	.92	.88	.84	.81	.77	.73	.69	.65	.61	.58	.54	.50	.46	.42	.38	.35	.31	.27	.23	.19	.15	.11	.08	.04	.00
2.4	1.20	1.16	1.12	1.08	1.04	1.00	.96	.92	.88	.84	.80	.76	.72	.68	.64	.60	.56	.52	.48	.44	.40	.36	.32	.28	.24	.20	.16	.12	.08	.04	.00
2.5	1.25	1.21	1.17	1.13	1.08	1.04	1.00	.96	.92	.87	.83	.79	.75	.71	.67	.62	.58	.54	.50	.46	.42	.37	.33	.29	.25	.21	.17	.12	.08	.04	.00
2.6	1.30	1.26	1.21	1.17	1.13	1.08	1.04	1.00	.95	.91	.87	.82	.78	.74	.69	.65	.61	.56	.52	.48	.43	.39	.35	.30	.26	.22	.17	.13	.09	.04	.00
2.7	1.35	1.30	1.26	1.21	1.17	1.12	1.08	1.03	.99	.94	.90	.85	.81	.76	.72	.67	.63	.58	.54	.49	.45	.40	.36	.31	.27	.22	.18	.13	.09	.04	.00
2.8	1.40	1.35	1.31	1.26	1.21	1.17	1.12	1.07	1.03	.98	.93	.89	.84	.79	.75	.70	.65	.61	.56	.51	.47	.42	.37	.33	.28	.23	.19	.14	.09	.05	.00
2.9	1.45	1.40	1.35	1.30	1.26	1.21	1.16	1.11	1.06	1.01	.97	.92	.87	.82	.77	.72	.68	.63	.58	.53	.48	.43	.39	.34	.29	.24	.19	.14	.10	.05	.00
3.0	1.50	1.45	1.40	1.35	1.30	1.25	1.20	1.15	1.10	1.05	1.00	.95	.90	.85	.80	.75	.70	.65	.60	.55	.50	.45	.40	.35	.30	.25	.20	.15	.10	.05	.00
$b \sim f$.	60″	55″	50″	45″	40″	35″	30″	25″	20″	15″	10″	05″	60″	55″	50″	45″	40″	35″	30″	25″	20″	15″	10″	05″	60″	55″	50″	45″	40″	35″	30″
	4′												3′												2′						

APPENDIX No. 9.

CONNECTION AT LAKE ONTARIO OF THE PRIMARY TRIANGULATION OF THE COAST AND GEODETIC SURVEY WITH THAT OF THE LAKE SURVEY.

Observations by CHARLES O. BOUTELLE, Assistant.

Discussion by CHARLES A. SCHOTT, Assistant.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington, March 27, 1884.

SIR: I have the honor to forward with this letter, the report of the computing division on the connection between the respective triangulations of the Coast and Geodetic Survey and the Lake Survey at Lake Ontario. The close agreement shown between these two entirely independent systems of surveys is highly gratifying, and adds largely to the rapidly increasing mass of data bearing on the true dimension and figure of that part of the earth covered by geodetic operations in this country.

Yours, respectfully,

C. O. BOUTELLE,
Assistant in charge of Office.

Prof. J. E. HILGARD,
Superintendent United States Coast and Geodetic Survey.

COAST AND GEODETIC SURVEY OFFICE,
Computing Division, March 27, 1884.

DEAR SIR: The office computation of the triangulation connecting Lakes Champlain and Onatrio has just been completed by Mr. Doolittle. The rapidity and correctness with which the work was executed are very creditable to the computer. The following results, comparisons, and remarks are respectfully submitted.

The total development is about 150 statute miles, and all needful particulars about the stations are shown on the accompanying triangulation sketch. (See plate No. 20.)

The horizontal directions at each station were adjusted as usual; the probable error of an observation of a direction* (consisting of pointing and reading, telescope D, and pointing and reading, telescope R) comes out as follows:

Station.	Probable error.	Station.	Probable error.
	"		"
Prospect	$e_1 = \pm 0.51$	Florence.	$e_1 = \pm 0.64$
Helderberg	0.59	Loomis.	0.58
Mount Hamilton	0.74	Howlett.	0.80
Otsego	0.67	Oswego.	0.63
Tassel	0.70	Victory.	0.60
Pen Mountain	0.67	Clyde.	0.54
Fenner	0.68		

All measures were taken with the 20-inch (50 cm.) Würdemann-Lingke theodolite C. S., No. 113.

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* Determined by $e_1 = \sqrt{\frac{.455 \Sigma \Delta^2}{n-s-d+1}}$ where n = number of observations, s = number of series, d = number of directions.

The average value of e_1 is $\pm$ 0''.64 This involves 12 divisions of the circle. At Mount Hamilton two station adjustments were made, one with the direction to Pen Mountain without distinction as to day or night-measures, the other splitting the direction in two; one for night, the other for day. The results are shown in the following table:

Summary of resulting directions at Mount Hamilton.

Directions.	First station adjustment.				Second station adjustment.		Remark.
	°	′	″	″	″	″	
Mark	0	00	00.000	±0.082	00.000 ±	0.072	Having in second adjustment introduced one more unknown quantity to be determined, the probable errors on the average must be smaller.
Prospect	101	52	05.357	.134	05.365	.129	
Helderberg	174	50	31.735	.131	31.536	.112	
Otsego	214	56	25.123	.138	24.936	.128	
Tassel	249	39	02.725	.146	02.888	.154	
Pen Mountain. { night	280	53	04.712*	.332	02.970	.291	
Pen Mountain. { day					06.645	.354	
				△=	3.675		

By request of the observer no use was made of the resulting direction from day measures in the present figure adjustment, but the value* had been used in the first office adjustment then terminating with the line Pen Mountain to Tassel.† The difference in the two adjustments for the observed direction is 1''.742, by which amount (nearly) each of the two triangles Pen Mountain, Mount Hamilton, Otsego and Pen Mountain, Mount Hamilton, Tassel are improved in the sum of their angles; the side equation involved is also improved. The present adjustment gives but the trifling correction of —0''.061 to the observed night-direction. Between the sides Prospect-Helderberg and Oswego-Sodus there are 4 quadrilaterals with a pentagon including a quadrilateral, giving rise to 24 conditions; these were satisfied by application of the method of least squares.

No notice was taken of the direction Loomis to Mannsville.

The triangulation of the United States Lake Survey joins that of the Coast and Geodetic Survey in a figure around the central station Victory. The adjusted triangles of the Lake Survey, which connect the Sandy Creek base with the line Sodus-Oswego, selected to show the closeness of agreement, were verified and recomputed. We have the following comparisons:

	Log distance Sodus-Oswego.	Distance.
		Meters.
Coast and Geodetic Survey.	4.7096864	51249.12
Lake Survey.	4.7096782	51248.15
Difference.	82	0.97

or $\frac{1}{52833}$ of the length, a satisfactory agreement.

The discord between the Buffalo base and the Sandy Creek base, as distributed in the Lake Survey, diminishes the above difference of 82 to 75. For the shorter interior sides Victory-Oswego and Clyde-Victory we have, respectively:

	Log distance Victory Oswego.	Log distance Clyde-Victory.
Coast and Geodetic Survey.	4.4168473	4.4471660
Lake Survey.	4.4168418	4.4471557
Difference.	55	103

†The use of the combined measures, generally followed by me, but subject to modification in special cases, is based upon the hypothesis that lateral refraction is referable to undue heating of a part of the ground (bare) close to and over which the line passes comparatively near to the observing station, and that consequently the opposite effect may be expected at night from undue cooling (radiation) of the same ground; now observations are not generally made either during the day or during the night about the times of maximum disturbing effect, so that it may reasonably be supposed that compensation takes place only partly. During cloudy days the phenomenon is supposed to disappear and to reach a maximum during clear weather. The time of change from one curvature into the opposite one may take place in the early night hours. Unequal distribution of aqueous vapor may also contribute to the phenomenon.

The linear comparison first given, when expressed in a familiar form, amounts to 19 millimeters per kilometer (or to 1.2 inches per statute mile).

The United States Lake Survey triangulation is developed on the Clarke spheroid of 1866 (same as ours), hence direct comparisons can be made between the results of the two surveys:

	Sodus.		Oswego.	
	φ	λ	φ	λ
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
Coast and Geodetic Survey.	43 14 13.724	77 04 43.628	43 26 37.313	76 30 49.281
Lake Survey.	43 14 13.74	77 04 44.74	43 26 37.28	76 30 50.41
Difference.	—0.02	—1.11	+0.03	—1.13

Which shows that the Lake Survey standard values for $\varphi_{\circ}$ and $\lambda_{\circ}$ agree well with our standard values.

	Sodus to Oswego.	
	α	α_1
	° ′ ″	° ′ ″
Coast and Geodetic Survey.	243 12* 21.401	63 35 37.646
Lake Survey.	243 12 26.58	63 35 42.81
Difference.	—5.18	—5.16

This azimuth comparison is less favorable than the position comparison, yet the correction to the triangulation would be small *if we were* to adjust distance and azimuth and have 26 in the plae of 24 conditions.

The following is added as further illustrating the character of the work. The mean error m of an angle is frequently employed as a characteristic of accuracy of the angular measures of a triangulation. Supposing the directions observed at each station adjusted (Bessel's method), then the additional corrections demanded by the subsequent figure adjustment will give a value of m, viz:

$$m=\sqrt{\frac{2\Sigma cc}{n_e}}$$

where Σcc = sum of squares of corrections to directions and n_e = number of conditions in the figure, or we may use with sufficient accuracy

$$m=1.253\sqrt{\frac{2}{ns}}.\Sigma(c)$$

where $\Sigma(c)$ = sum of corrections without regard to sign, n = number of conditions and s = number of directions in the figure.

In our case we have with $n_e = n = 24$ and $s = 60$ the values $m = \pm\ 0''.986$ and $m = \pm\ 0''.95$ by the first and second formula, respectively.*

We may also note the result that of the 23 triangles the closing error is 15 times positive and but 8 times negative. This may be accidental. The four greatest closing errors are $+2''.854$, $-2''.481$, $+2''.443$, and $-2''.223$ The three greatest corrections to a direction are $+1''.079$ (Prospect to Otsego), $-''.907$ (Clyde to Victory), and $-0''.801$ (Florence to Howlett).

The positions of 12 new principal and of 20 subordinate points have been inserted in the registers.

*For comparison: "Horseshoe" triangulation in Pennsylvania, $m = \pm\ 1''.75$ (in my report of August 16, 1883, the *probable* error corresponding to this *mean* error had been given); Bessel's Gradmessung $m = \pm\ 0''.77$ (as stated by Jordan); British Ord. Sur., $m = \pm\ 2''.21$ (as stated by Jordan).

In connection with the Champlain-Ontario branch triangulation, it may be remarked that th country between its western part, where the Pamplico-Chesapeake arc of the meridian intersect it, and the Pennsylvania line has already been reconnoitered by the New York State Survey.

Having secured a satisfactory junction with the Lake Survey, we may advance a step furthe as shown in the following preliminary comparison:

Junction of triangulations in Illinois of the Coast and Geodetic Survey transcontinental triangulati (through Assistant Fairfield's field computation) and the Lake Survey arc of the meridian, vicini of the Olney base.

	Denver.						Claremont.						Denver to Claremont.					
	ϕ			λ			ϕ			λ			α			α_1		
	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″
Coast and Geodetic Survey	38	46	22.75	88	12	41.91	38	45	33.33	87	59	39.02	274	32	30.3	94	40	40.5
Lake Survey	38	46	18.16	88	12	44.38	38	45	28.75	87	59	41.54	274	32	26.8	94	40	37.0
Difference			+4.59			−2.47			+4.58			−2.52			+3.5			+3.5

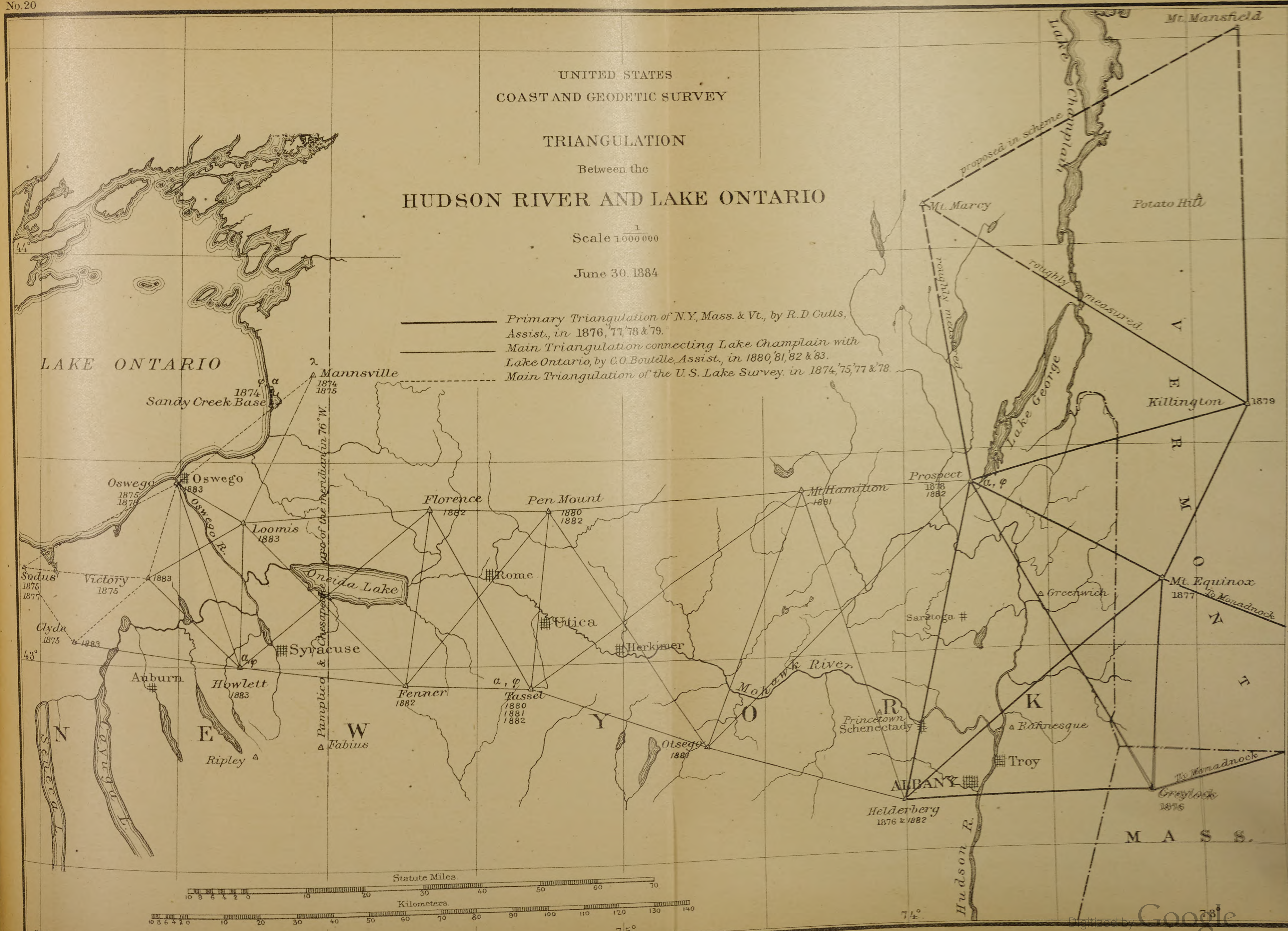
These rough comparisons are quite satisfactory, and in particular the longitudinal differenc which is of great importance in our own line; it may be reduced to $-1''.4$ by applying the co rection found at Oswego. The spheroid employed in both surveys appears to answer for th western region.

Our knowledge of the western boundary line of Pennsylvania, which is connected with th Lake Survey, will also be improved, since a comparison of geodetic and astronomical longitude may now be made by the Boundary Commission.

Yours, respectfully,

CHAS. A. SCHOTT,
Assistant, in charge Computing Division.

C. O. BOUTELLE, Esq.,
Assistant, in charge Office and Topography.


UNITED STATES
COAST AND GEODETIC SURVEY
TRIANGULATION
Between the
HUDSON RIVER AND LAKE ONTARIO
Scale 1/1000000
June 30. 1884
Primary Triangulation of N.Y., Mass. & Vt., by R. D. Cutts, Assist., in 1876, '77, '78 & '79.
Main Triangulation connecting Lake Champlain with Lake Ontario, by C. O. Boutelle, Assist., in 1880, '81, '82 & '83.
Main Triangulation of the U. S. Lake Survey in 1874, '75, '77 & '78.
LAKE ONTARIO
Sandy Creek Base
1874
Mannsville
1874
1875
Oswego
1875
1878
1883
Loomis
1883
Florence
1882
Pen Mount
1880
1882
Mt. Hamilton
1881
Prospect
1878
1882
Mt. Marcy
proposed in scheme
roughly measured
Lake Champlain
Lake George
Mt. Mansfield
Potato Hill
Killington
1879
Mt. Equinox
1877
To Monadnock
Greenwich
Saratoga
Sodus
1875
1877
Victory
1875
1883
Clyde
1875
1883
Oneida Lake
Rome
Utica
Herkimer
Mohawk River
Syracuse
Howlett
1883
Auburn
Fenner
1882
Tasset
1880
1881
1882
Otsego
1881
Fabius
Ripley
Pamplico & Chesapeake arc of the meridian in 76° W.
Oswego R.
Seneca L.
Cayuga L.
Princetown
Schenectady
Rafinesque
Troy
ALBANY
Helderberg
1876 & 1882
Greylock
1876
Hudson R.
N E W Y O R K
V E R M O N T
M A S S.
44°
43°
77°
76°
75°
74°
73°
Statute Miles
Kilometers

APPENDIX No. 10.

RESULTS OF A TRIGONOMETRICAL DETERMINATION OF THE HEIGHTS OF THE STATIONS FORMING THE DAVIDSON QUADRILATERALS. CALIFORNIA.

Observations by GEORGE DAVIDSON, Assistant, 1876-1882.

Discussion by CHARLES A. SCHOTT, Assistant, 1884.

COAST AND GEODETIC SURVEY OFFICE,
Computing Division, October 14, 1884.

This trigonometrical determination of heights is based upon stations connected by spirit-level with the average or half-tide surface of the ocean. Up to date the heights of four* of the trigonometrical points have been determined by direct leveling from the ocean; they are:

	Meters.
Southeast Yolo Base above half-tide level of the ocean	21.66
Northwest Yolo Base	46.66
Mount Diablo	1173.10
Ross Mountain	672.23

The heights of the other trigonometrical stations† above the average sea level depend on measures of zenith distances and are based upon the above stations whose elevations had become known by spirit leveling.

The large scale upon which the geodetic work is being carried out in the central part of California, the peculiarity of the climate of this part of the State and our consequent imperfect knowledge of the atmospheric refraction, coupled with the fact that zenith distances were observed nearly at all hours of the day between sunrise and sunset, and that no simultaneous reciprocal measures were taken, renders the application of the ordinary method of reduction somewhat hazardous and difficult. To compute differences of heights up to 3000 meters and involving zenith distances taken only at one end of lines as great in length as 142 statute miles or 229 kilometers was heretofore hardly considered a practical undertaking; yet we shall see from the success attained that our former ideas as to the limiting range of useful applicability of the trigonometrical method need to be considerably expanded. The possibility of computing the heights of the stations with the desirable degree of accuracy is mainly due to the excellent series of hourly and simultaneous reciprocal hypsometric observations made by Assistant G. Davidson's party on Mount Diablo and at Martinez East, California, in 1880. The measures were discussed at length by me and published in Coast and Geodetic Survey Report for 1883, Appendix No. 12. These observations and results constitute a decided advance in geodetic hypsometry and they have enabled me to give a practical test to the theory of refraction as presented by Dr. W. Jordan‡ by applying to it the results to the vertical measures of the primary triangulation of Central California.

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* See Coast and Geodetic Survey Report for 1883, Appendix No. 12, p. 290, and Coast and Geodetic Survey Report for 1876, Appendix No. 16, p. 339.

† For triangulation sketch see Coast and Geodetic Survey Report for 1884 plate No. 18.

‡ First published in the Astronomische Nachrichten No. 2095, vol. 88. pp. 99–108, May, 1876. Prof. C. Fearnley's contribution to the theory of terrestrial refraction appended to the proceedings of the Seventh International Geodetic Conference at Rome, 1883, Berlin, 1884, was received too late for consideration in the present paper [Nov., 1881.—Sch. —]

The theory itself starts from Laplace's differential equation to a ray of light passing through ou atmosphere, and after introducing certain simplifications for the purpose of adapting the expressioı to terrestrial refraction, the meteorological elements are introduced by means of the expression o the ratio of density of the air at the upper and lower stations. Full use is made of the author' barometric formula, but the distinctive feature of the method lies in the direct introduction o the law of decrease of atmospheric temperature with altitude—all of which has been referred to iı Appendix No. 12, Report for 1883 (pp. 308–313.)

In the absence of simultaneous reciprocal measures of zenith distances we are obliged t procure in some way suitable values for the coefficient of refraction; even were such observation available, the knowledge of this coefficient could only be dispensed with in the computation fo differences of heights under certain restrictions, viz, we have to assume its value to be the sam at the upper and at the lower station and take the path of the pencil of light to be part of an ar of a circle.

It would therefore appear preferable in all cases to secure by the best means at our commanc such values of the coefficient as will be most consistent with or conform most nearly to the actua state of the atmosphere at the time. In case of reciprocal or double measures, simultaneous oı not, we shall obtain two independent values for the difference of heights, viz, h_2-h_1 and h_1-h_2, the weighted mean of which results may be taken for the final value $\triangle h$.

To introduce the results of the Mount Diablo and Martinez East observations, or of similaı observations at Round Top and Jackson Butte, Cal., and to accommodate Jordan's formulæ t practical computation applicable to the particular region under consideration, we proceed a follows:

Putting the minor terms with the factor 18400 occurring in the author's formula for the com putation of heights from barometric measures, viz,

$$18400\left(1+.377\frac{e}{p}\right)(1+.002573\cos 2\varphi)\left(1+\frac{2\,\mathrm{H}}{r}\right)$$

equal to K, so that the complete formula for the difference of height would read *

$$\triangle h=\mathrm{K}\log\frac{\mathrm{P}}{\mathrm{P}'}(1+.003665\,t)$$

The value of K and consequently also that of MK, where M is the logarithmic modulus, may be taken as constant for any limited region under the same climatic conditions. For Central Cali fornia we may put for the mean vapor pressure in the ratio $\frac{e}{p}$ the value $e=7.5$ millimeter and corresponding to it the mean atmospheric pressure = 750 millimeters (or for any higher leve we may use the ratio $\frac{5.5}{550}$); hence we take $\frac{e}{p}=\frac{1}{100}$, we put φ or the average latitude equal t 39°, then for various average altitudes $\mathrm{H}=\frac{h+h_1}{2}$ we find K with $\log \mathrm{M}=9.63778$ and $r=637100($ meters, which is very nearly the radius of a sphere, having about the same surface and volume as the earth, considered as a spheroid of the dimensions assigned by Clarke.

With sufficient accuracy for our purpose, we may take log MK = 3.9046 or use the tabulaı values below.

For H = 500 m.	Log M K = 3.90453
1000	60
2000	74
3000	88

* Appendix No. 12, Coast and Geodetic Survey Report for 1883, p. 305.

† One minute of arc on the surface of such a sphere is 1853^{m}.248 in the case of surface equality and 1853^{m}.24(in the case of volume equality. Hence, $\log r=6.8042072$

The coefficient of refraction m is given by the expression:

$$2\,m = k = \frac{c\,P}{1+\varepsilon T}\left(\frac{1-\varepsilon T}{MK} - \tau\,\varepsilon\right) r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where c = a constant $= \frac{.00029286}{760}$ hence $\log c = 3.58585 - 10$, and ε = a constant = .003665

P = atmospheric pressure in millimeters (mercurial column reduced to temperature 0° C),

T = atmospheric temperature in centigrade degrees,

$\tau = \frac{d\,T}{d\,h}$ nearly, it indicates the average rate of change in the temperature of the air for a given rise in altitude. The following values of τ for every hour of the day and for a rise of $d\,h = 1\,m$ as resulting from the Mount Diablo–Martinez East observations are taken from Table XXI, p. 311, of the appendix referred to above. They are:

Hour.	$\tau = \frac{\tau_1 + \tau_2}{2}$	τ observed.	Hour.	$\tau = \frac{\tau_1 + \tau_2}{2}$	T observed.
	°	°		°	°
6 a. m.	− .0002	+ .0013	1 p. m.	+ .0056	+ .0042
7 a. m.	.0002	15	2 p. m.	64	53
8 a. m.	+ .0008	12	3 p. m.	62	62
9 a. m.	.0014	11	4 p. m.	61	61
10 a. m.	.0023	11	5 p. m.	55	62
11 a. m.	.0038	17	6 p. m.	37	55
Noon.	+ .0048	+.0032	7 p. m.	+.0020	+.0043

where the values of τ first given are mean values for the strata of air immediately above the upper and lower stations and the second set of values of τ are those answering directly to the observed ratio for the whole intervening stratum of air or to $\frac{T - T_1}{\triangle h}$. For the present application preference is given to the second set of values.

$$\text{Putting } \frac{c\,r}{1+\varepsilon T} = f \text{ and } \frac{1-\varepsilon T}{MK} = g$$

the factors f and g can be tabulated for the argument T, and we have for the computation of the coefficient of refraction the convenient form:

$$2\,m = k = f\,P\,(g - \tau\,\varepsilon) \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

For the difference of height the usual expression has been expanded* to

$$h_1 - h = \triangle h = s\left(1 + \frac{h+h_1}{2\rho}\right)\cot\zeta + \frac{1-2\,m}{2\rho}\,s^2\left(1+\frac{h+h_1}{2\rho}\right)^2 + \left(\frac{1-2\,m}{2\rho}\right)^2 s^3\cot\zeta$$

* Derived from the equation $h_1 - h = \triangle h = s\left(1+\frac{h+h_1}{2\rho}\right)\cot\left(\zeta - \frac{1-2\,m}{2}\,\psi\right)$ directly from the geometrical conditions. Putting the angle at the center $\psi = \frac{s}{\rho}$ and developing $\cot\left(\zeta - \frac{1-2\,m}{2\rho}\,s\right)$ into a series, we have:

$$\cot\left(\zeta - \frac{1-2\,m}{2\rho}\,s\right) = \cot\zeta + \frac{1-2\,m}{2\rho}\cdot\frac{s}{\sin^2\zeta} + \left(\frac{1-2\,m}{2\rho}\right)^2\cdot\frac{s^2\cos}{\sin^3\zeta} + \;.\;.\;.\;.$$

and with $\sin^2\zeta = 1$

$$h_1 - h = s\left(1+\frac{h+h_1}{2\rho}\right)\left[\cot\zeta + \frac{1-2\,m}{2\rho} + \left(\frac{1-2\,m}{2\rho}\right)^2 s^2\cot\zeta \;.\;.\;.\right]$$

$$h_1 - h = s\left(1+\frac{h+h_1}{2\rho}\right)\cot\zeta + \frac{1-2\,m}{2\rho}\,s^2\left(1+\frac{h+h_1}{2\rho}\right)^2 + \left(\frac{1-2\,m}{2\rho}\right)^2 s^3\cot\zeta$$

Auxiliary tables.

Local hour.	From Mount Diablo Martinez East series. $\tau\epsilon$.	From mean of Mount Diablo, Martinez East and Round Top Jackson Butte series. $\tau\epsilon$.	T	g	Log. f.
6 a. m.	+.000 0048	+.000 0134	0 ° C	.000 1246	0.3904
6.5 a. m.	0051	0138	1	1241	888
7 a. m.	0055	0142	2	1237	872
7.5 a. m.	0050	0142	3	1232	856
8 a. m.	0044	0143	4	1228	841
8.5 a. m.	0042	0138	5	1223	825
9 a. m.	0040	0134	6	1218	810
9.5 a. m.	0040	0135	7	1214	794
10 a. m.	0040	0135	8	1209	779
10.5 a. m.	0051	0142	9	1204	763
11 a. m.	0062	0149	10	.000 1200	0.3748
11.5 a. m.	0090	0163	11	1195	733
Noon.	+.000 0117	+.000 0177	12	1191	718
0.5 p. m.	0136	0189	13	1186	702
1 p. m.	0154	0200	14	1182	687
1.5 p. m.	0174	0213	15	1177	672
2 p. m.	0194	0226	16	1173	657
2.5 p. m.	0210	0235	17	1168	642
3 p. m.	0227	0244	18	1164	627
3.5 p. m.	0226	0243	19	1159	612
4 p. m.	0224	0242	20	.000 1155	0.3597
4.5 p. m.	0224	0241	21	1150	582
5 p. m.	0224	0240	22	1146	567
5.5 p. m.	0213	0232	23	1141	552
6 p. m.	0202	0224	24	1137	538
6.5 p. m.	0180	0211	25	1132	523
7 p. m.	+.000 0158	+.000 0197	26	1128	508
			27	1123	494
			28	1118	480
			29	1114	465
			30	.000 1109	0.3451
			31	1104	437
			32	1100	423
			33	1095	408
			34	1091	394
			35	1086	380

Log. $\left(1 + \frac{h + h_1}{2\rho}\right)$. Argument $\frac{h + h_1}{2}$ with $\rho = 6\ 371\ 000\,m$.

$\frac{h+h_1}{2}$	0	100	200	300	400	500	600	700	800	900
m 0	.00000	.00001	.00001	.00002	.00003	.00003	.00004	.00005	.00005	.00006
1000	07	07	08	09	10	10	11	12	12	13
2000	14	14	15	16	16	17	18	18	19	20
3000	20	21	22	22	23	24	25	25	26	27
4000	27	28	29	29	30	31	32	32	33	33
5000	34	35	36	36	37	37	38	39	39	40

log ρ.			
Middle latitude.	38°	39°	40°
Meridian	6.80342	6.80350	6.80357
$a=5°$	344	351	359
10	348	355	363
15	355	362	369
20	364	371	378
25	375	382	388
30	388	394	401
35	402	408	414
40	418	423	429
45	434	439	444
50	450	454	459
55	465	469	474
60	480	484	487
65	493	496	500
70	504	507	510
75	513	516	519
80	520	523	525
85	524	527	529
Perpendicular	526	528	531

In case of simultaneous reciprocal zenith distances at the termini of a line, we have for the lower and upper stations respectively:

$$2m_1=k_1=f_1\,P_1\,(g_1-\tau_1\,\varepsilon) \qquad\qquad 2m_2=k_2=f_2\,P_2\,(g_2-\tau_2\,\varepsilon)$$

and compute the coefficients of refraction from

$$m'=\frac{2m_1+m_2}{3} \qquad\qquad m''=\frac{2m_2+m_1}{3}$$

hence, difference of heights

$$\begin{cases} h_2-h_1=s_0\cot\zeta_1+\dfrac{1-2m'}{2\rho_1}s_0^2+\left(\dfrac{1-2m'}{2\rho_1}\right)^2 s^3\cot\zeta \\[2ex] h_1-h_2=s_0\cot\zeta_2+\dfrac{1-2m''}{2\rho_2}s_0^2+\left(\dfrac{1-2m''}{2\rho_2}\right)^2 s^3\cot\zeta \end{cases}$$

where s_0 equals the horizontal distance at the middle height of the stations. It is obvious that for one-sided zenith distances the pressure P and temperature T could be deduced approximately for the opposite station by means of a knowledge of an approximate value for $\triangle h$, which may be found with sufficient accuracy by

$$\triangle h=18400\log\frac{P_1}{P_2}\,(1+.003665\,t)$$

where T is found by means of the values of τ and the observed temperature at the occupied station, whence t, which is the mean of the two temperatures; the values of m' and m'' may then be employed in preference to m. The utility of this proceeding may be considered as depending on special circumstances; it has *not been employed* in the present investigation.

ABSTRACT OF RESULTING VERTICAL MEASURES AND COMPUTATION OF HEIGHTS OF STATIONS FORMING THE DAVIDSON QUADRILATERALS, CALIFORNIA.

The stations are as follows: Southeast Yolo Base, Northwest Yolo Base, Monticello, Vaca, Mount Diablo, Mount Helena, Mount Tamalpais, Ross Mountain, Mount Lola and Round Top. There are also two intermediate, as yet unoccupied stations, viz, Pine Hill and Marysville Butte, and there is Jackson Butte used for hypsometric observations in connection with Round Top—these are useful stations in the adjustment of heights and will therefore be included in our discussion.

In order to render this account of the determinations of heights as useful as possible, it is proposed to give first a specimen of part of the record, also specimens of abstracts of results; next a statement of the reduced measures and computed differences of heights, and finally their least square adjustment.

Specimen of record.

DOUBLE ZENITH DISTANCES.

[Station, Vaca (eccentric *). Date, Wednesday, November 3, 1880. Observer, E. F. Dickins (G. Davidson in charge of party). Instrument, 25 cm. Gambey Vertical Circle,† C. S. No. 80.]

Object observed.	Rep's.	Local time.	Level. O.	Level. E.	R. or L.	Circle.	Mean.	Zenith distance.	Remarks.
Southeast Yolo Base, N.‡ *m*−*d*. *m*−*st* ..	0	*p. m.* $4^h 25^m$			R	A 0° 00′ 15″	09″.7		Instrument adjusted before beginning observations. The verniers read to 3″. One division of level scale =3″.8
						B 12			Observations taken in sets of 3 repetitions of the double zenith distance, first pointing always with vertical circle to the right (R), levels are read on the first and last pointing of each set.
						C 03			
						D 09			
Southeast Yolo Base, N.‡ *m*−*d*. *m*−*st*...	3	$4^h 27^m$	$10^d.1$	$10^d.5$	R	A 188° 41′ 12″	04″.5	91° 26′ 49.1″	
			9.2	11.3	L	B 06		Level correction, + 2.4	
						C 00		51.5	Barometric pressure, in. 27.67
						D 00			
Southeast Yolo Base, N.‡ *m*−*d*. *m*−*st*...	3	$4^h 35^m$	10.6	10.0	R	A 17° 21′ 57″	42″.7	91° 26′ 46.4″	Attached thermometer, °F. 71.1
			9.0	12.0	L	B 42		Level correction, + 2.3	Dry-bulb thermometer, 64.8
						C 36		48.7	Wet-bulb thermometer, 51.0
						D 36			Wind, northwest, fresh.

* Vertical angle pier S 6° 02′ E and $15^m.9$ distant from center of station (△).
† Axis of telescope $1^m.310$ above copper bolt of station Vaca △.
‡ Heliotrope $10^m.515$ above △ of southeast base.

Specimen of abstract of resulting daily measures of the zenith distance of the same object.

[Station Vaca, eccentric. Observed zenith distances of station southeast Yolo Base.]

Number.	Date.	Time of first measure.	Time of second measure.	Mercurial barometer.	Atmospheric thermometer.	Dry bulb.	Wet bulb.	Zenith distances. First measure.	Zenith distances. Second measure.	Zenith distances. Mean.
	1880.	h. m.	h. m.	In.	° F.	° F.	° F.	° ′ ″	″	″
1	November 3, p. m.	4 27	4 35	27.67	71.1	64.8	51.0	91 26 51.5	48.7	50.1
2.	November 4, p. m.	3 35	3 44	.63	66.7	65.2	45.9	47.6	47.8	47.7
3	November 5, p. m.	1 38	1 44	.77	76.9	70.6	51.3	55.0	52.8	53.9
4	November 6, p. m.	2 04	2 10	.78	75.9	69.1	52.4	50.6	53.5	52.0
5	November 7, p. m.	1 51	1 57	.72	81.5	70.4	55.1	34.0	41.9	37.9
6	November 8, p. m.	1 48	1 57	.66	66.3	63.0	42.4	53.0	52.0	52.5
7	November 9, p. m.	1 46	1 52	.65	74.5	64.2	53.1	53.7	52.9	53.3
8	November 10, p. m.	1 53	1 59	.71	62.0	53.6	40.0	52.1	51.1	51.6
9	November 11, p. m.	1 54	2 01	.73	57.9	51.1	37.3	51.2	52.6	51.9
10	November 24, p. m.	3 00	3 10	.58	51.0	45.8	34.0	50.2	51.8	51.0
		Mean, by days,		27.69	68.4	61.8	46.2	91° 26′		50.2

At this station (Vaca) there were eight such objects observed as above.

The next step is to compute the following quantities required in the reduction, viz:

1. The eccentric distance s_e between the vertical circle and the heliotrope at the distant station. This is effected with all needful accuracy by letting fall a perpendicular from the eccentric station occupied to the line centrally joining the two stations. The distance and azimuth of the eccentricity being known, as well as the azimuth of the line, the distance of this foot-point from the central station △ is added or subtracted (as the case may be) from the horizontal distance s between the stations, as given by triangulation. Thus, the distance s_e from eccentric station A to heliotrope at B is not the same as s_e between the eccentric station B and the heliotrope at A. It will be found convenient to make use of the formula $\log(s+\triangle s)=\log s+M\frac{\triangle s}{s}$, very nearly.

2. The observed zenith distances are reduced to the ground or station mark △, *i. e.*, for height of vertical circle above this point; and they are also reduced to the station mark at the distant station, *i. e.*, for height of heliotrope above that mark.

3. By means of tables the mean values of the readings of the mercurial barometer are reduced to the freezing temperature, and the resulting height of the column is converted into millimeters; the mean temperature of the air is expressed in centigrade degrees. The effect of difference of moisture and of variation of gravity at any two connected stations may be neglected in the present application.

4. To the above quantities is added the mean value of $\tau\varepsilon$ taken from the table with the argument time of day; thus, for the above example we have the ten values $10^7\ \varepsilon\tau=224$, 225, 181, 196 190, 190, 190, 194, 194, 227; mean, 201. For the stations east of Mount Diablo the second table for $10^7\ \varepsilon\tau$ has been used, also for the Ross Mountain connection. The values of ρ are likewise tabulated; argument, mean latitude and azimuth.

We have the following abstracts of resulting data for computation of heights:

Abstracts of resulting zenith distances and of other data for the computation of heights involved in the Davidson quadrilaterals.

[*Southeast Yolo Base.* August, 1880. Vertical Circle No. 80.]

Number of days.	Object observed.	Observed zenith distance.	Reduction to level of △.	Reduced ζ.	P.	T.	$10^7\ \varepsilon\tau$.	Log s_e.
		° ′ ″	″	° ′ ″	*mm.*	°*C.*		
8	Northwest Yolo Base	89 59 56.7	+14.6	90 00 11.3	750	32.2	229	4.243236
7	Mount Diablo	89 21 53.7	— 4.6	89 21 49.1	750	33.2	221	4.859804
6	Marysville Butte	89 49 20.4	— 4.0	89 49 16.4	751	32.4	236	4.876708
8	Vaca	88 46 02.0	—11.9	88 45 50.1	751	33.4	219	4.477558
8	Monticello	88 44 35.0	—10.4	88.44 24.6	750	32.7	219	4.570313

[*Northwest Yolo Base.* August and September, 1880. Vertical Circle No. 80.]

10	Vaca	89 08 51.3	— 2.7	89 08 48.6	753	33.6	216	4.590894
8	Pine Hill	89 51 11.8	— 0.8	89 51 11.0	754	32.7	240	4.878871
11	Marysville Butte	89 38 29.2	— 0.8	89 38 28.4	753	33.6	240	4.767973
10	Southeast Yolo Base	90 07 40.2	+104.6	90 09 24.8	753	33.7	221	4.242594
9	Monticello	88 21 26.8	— 4.6	88 21 22.2	753	33.5	226	4.461052
6	Mount Diablo	89 36 44.0	— 0.9	89 36 43.1	754	31.3	220	4.947430

[*Monticello.* October, 1880. Vertical Circle No. 80.]

8	Northwest Yolo Base	91 51 38.9	+19.6	91 51 58.5	682	18.6	225	4.460831
8	Southeast Yolo Base	91 31 56.0	+50.8	91 32 46.8	682	18.9	221	4.569880
8	Mount Helena	89 34 05.1	− 0.1	89 34 05.0	682	19.2	214	4.586474
7	Mount Diablo	90 11 47.9	— 0.2	90 11 47.7	683	18.8	220	4.954636
6	Mount Tamalpais	90 26 19.3	— 1.0	90 26 18.3	682	18.2	224	4.951669
8	Marysville Butte	90 30 11.4	+ 0.2	90 30 11.6	682	18.3	239	4.833754
6	Vaca	90 28 45.0	— 1.3	90 28 43.7	683	19.9	211	4.521833
7	Pine Hill	90 33 37.4	0.0	90 33 37.4	682	18.1	240	5.019353

[*Vaca.* November, 1880. Vertical Circle No. 80.]

10	Southeast Yolo Base	91 26 50.2	+63.2	91 27 53.4	701	16.6	200	4.477660
10	Northwest Yolo Base	91 08 57.4	+14.9	91 09 12.3	701	15.6	212	4.591052
9	Monticello	89 46 57.0	0.0	89 46 57.0	701	17.2	167	4.522277
10	Mount Diablo	89 46 02.7	— 0.1	89 46 02.6	701	15.7	203	4.754460
8	Marysville Butte	90 25 03.6	+ 0.3	90 25 03.9	701	14.4	237	4.977639
7	Mount Tamalpais	90 12 27.3	— 1.1	90 12 26.2	701	14.4	188	4.827909
5	Pine Hill	90 26 30.5	+ 0.1	90 26 30.6	700	16.0	239	5.011729
10	Mount Helena	89 38 12.7	+ 0.1	89 38 12.8	701	16.3	174	4.762834

Abstracts of resulting zenith distances and of other data for the computation of heights, &c.—Cont'd.

Number of days.	Object observed.	Observed zenith distance.	Reduction to level of △.	Reduced ζ.	P.	T.	10^7 εr.	Log s_e.
	[*Mount Tamalpais. * September and October, 1882. Vertical Circle No. 111.]**							
		° ′ ″	″	° ′ ″	mm.	°C.		
13	Mount Diablo	89 51 33.2	+0.3	89 51 33.5	694	21.2	133	4.779631
9	Mount Helena	89 56 54.0	+1.2	89 56 55.2	693	17.1	191	4.917994
7	Monticello	90 15 20.0	+0.3	90 15 20.3	694	18.4	169	4.951656
8	Vaca	90 18 32.4	+0.9	90 18 33.3	694	19.9	152	4.827912
7	Macho	90 08 43.6	......	....	.....	.....	.....	....
9	Ross Mountain	90 23 19.4	+1.5	90 23 20.9	693	18.7	213	4.898410
	[*Mount Diablo.* August and September, 1876. Vertical Circle No. 37.]							
8	Mount Helena	90 19 49.6	+4.9	90 19 54.5	662	19.1	131	5.032217
7	Mount Tamalpais	90 35 40.3	+9.0	90 35 49.3	662	17.9	178	4.779316
8	Monticello	90 29 43.5	+6.0	90 29 49.5	662	18.4	118	4.954650
8	Vaca	90 39 50.1	+9.5	90 39 59.6	662	19.0	154	4.754465
8	Round Top	90 06 57.4	+2.9	90 07 00.3	662	17.3	137	5.275549
6	Marysville Butte	90 45 37.8	+3.6	90 45 41.4	662	16.1	163	5.167936
6	Mount Lola	90 25 07.6	+2.3	90 25 09.9	661	16.2	144	5.339902
3	Pine Hill	90 43 25.1	+4.4	90 43 29.5	662	15.7	190	5.090642
6	Macho	90 07 54.3	......	....	.....	.....	.....	....
	[*Mount Helena.* October and November, 1876. Vertical Circle No. 37.]							
8	Mount Diablo	90 29 03.5	+1.8	90 29 05.3	652	10.7	133	5.032199
4	Mount Lola	90 24 27.7	+0.9	90 24 28.6	654	11.8	177	5.330129
10	Vaca	90 48 17.3	+3.7	90 48 21.0	652	10.6	118	4.762513
8	Marysville Butte	90 46 14.6	+2.2	90 46 16.8	652	9.1	191	4.965048
7	Snow Mountain, east	89 42 28.3	......	....	.....	.....	.....	....
8	Mount Tamalpais	90 40 46.8	+2.6	90 40 49.4	653	9.2	112	4.917929
9	Round Top	90 23 56.4	+0.9	90 23 57.3	652	8.3	177	4.359980
7	Monticello	90 43 32.1	—1.7	90 43 30.4	652	7.8	155	4.586067
6	Pine Hill	90 48 20.8	+1.5	90 48 22.3	654	10.8	179	5.155412
9	Ross Mountain	90 58 50.7	—1.4	90 58 49.3	653	9.3	194	4.664110
	[*Mount Lola.* July, 1879. Vertical Circle No. 80.]							
10	Pah Rah †	90 31 24.8	—0.3	90 31 24.5	.....	.....	.....	....
12	Mount Como †	90 22 53.3	—1.0	90 22 52.3	.....	.....	.....	....
11	Round Top	90 07 24.9	—0.6	90 07 24.3	546	12.2	218	4.959149
10	Pine Hill	91 40 21.9	—0.5	91 40 21.4	546	12.1	230	4.981950
10	Mount Diablo	91 16 15.5	—0.4	91 16 15.1	546	8.9	162	5.339834
10	Mount Helena	91 13 19.1	—0.3	91 13 18.8	546	7.9	152	5.330148
9	Marysville Butte	91 27 44.5	—0.5	91 27 44.0	546	10.2	208	5.107305
12	Snow Mountain, east	90 58 38.9	......	....	.....	.....	.....	....
10	Mount Linn	90 57 03.6	......	....	.....	.....	.....	....
	[*Round Top.* August, September and October, 1879. Vertical Circle No. 80.]							
19	Mount Lola	90 36 00.8	—0.2	90 36 00.6	524	12.1	206	4.959206
18	Mount Como †	90 38 13.6	—2.3	90 38 11.3	.....	.....	.....	....
19	Mount Grant †	90 16 45.7	+0.8	90 16 46.5	.....	.....	.....	....
20	Mount Conness ‡	89 59 36.4	—1.7	89 59 34.7	.....	.....	.....	....
14	Jackson Butte §	92 13 54.8	0.0	92 13 54.8	526	9.1	235	4.859571
16	Mount Diablo	91 20 17.6	0.0	91 20 17.6	523	6.8	144	5.275472
7	Mount Helena	91 20 36.6	0.0	91 20 36.6	521	4.6	147	5.360027
18	Pine Hill	92 01 30.8	+0.3	92 01 31.1	524	9.2	180	4.936030
9	Marysville Butte	91 30 34.1	0.0	91 30 34.1	522	5.1	152	5.227520
10	Snow Mountain, east	91 12 09.7	......	....	.....	.....	.....	....
16	Macho	91 19 05.2	......	....	.....	.....	.....	....
	[*Jackson Butte.* September, 1879. Vertical Circle No. 111.]							
7	Pine Hill	90 16 49.5	—1.0	90 16 48.5	701	28.6	140	4.683264
14	Round Top §	88 20 02.6	0.0	88 20 02.6	702	24.9	235	4.859537

* There are other stations observed upon from Mount Tamalpais, but omitted here, as they form no part of the quadrilaterals and consequently do not enter into the present discussion. The same remark applies to other stations. Mount Tamalpais was formerly called Table Mountain.

† Connecting primary stations of Nevada. ‡ Connecting primary stations of California and Nevada. § From special discussion.

A preliminary computation gave the values for approximate heights which were needed for the following steps. We have—

	m.		m.
Southeast Yolo Base	22	Mount Helena	1320
Northwest Yolo Base	47	Mount Lola	2790
Ross Mountain	672	Round Top	3170
Monticello	934	Marysville Butte	645
Vaca	730	Pine Hill	635
Mount Tamalpais	789	Jackson Butte	710
Mount Diablo	1173		

RESULTING DIFFERENCES OF HEIGHTS, from application of formulæ (2) and (3) to the preceding data of observation.

The column headed n gives the number of days of observation of zenith distances and is the weight for the combination of all double determinations of $\triangle h$, *i. e.*, by means of h_1-h and by means of $h-h_1$.

The resulting weighted mean, or $\frac{n \triangle h+n_1 \triangle h_1}{n+n_1}$ is given in the table of results.

Station.	n	Station.	n_1	Δh	$-\Delta h$	Weighted mean Δh.	$n+n_1$.	By spirit level.
				m	m	m		m
SOUTHEAST YOLO BASE.	8	Northwest Yolo Base.	10	+ 19.68	− 27.30	23.91	18	25.00
"	7	Mount Diablo.		+ 1157.50				1151.44
"	6	Marysville Butte.		+ 617.17				
"	8	Vaca.	10	+ 708.56	− 708.57	708.57	18	
"	8	Monticello.	8	+ 910.39	− 910.57	910.48	16	
NORTHWEST YOLO BASE.	10	Vaca.	10	+ 682.71	− 684.52	683.62	20	
"	8	Pine Hill.		+ 578.70				
"	11	Marysville Butte.		+ 599.18				
"	9	Monticello.	8	+ 885.82	− 885.81	885.82	17	
"	6	Mount Diablo.		+ 1126.74				1126.44
MONTICELLO.	8	Mount Helena.	7	+ 390.35	− 390.75	390.54	15	
"	7	Mount Diablo.	8	+ 234.67	− 245.29	240.33	15	
"	6	Mount Tamalpais.	7	− 148.50	+ 129.90	138.48	13	
"	8	Marysville Butte.		− 286.68				
"	6	Vaca.	9	− 203.84	+ 199.37	201.16	15	
"	7	Pine Hill.		− 291.07				
VACA.	10	Mount Diablo.	8	+ 444.32	− 446.09	445.11	18	
"	8	Marysville Butte.		− 92.96				
"	7	Mount Tamalpais.	8	+ 54.19	− 64.51	59.69	15	
"	5	Pine Hill.		− 90.91				
"	10	Mount Helena.	10	+ 587.59	− 595.23	591.41	20	
MOUNT TAMALPAIS.	13	Mount Diablo.	7	+ 386.09	− 386.19	386.12	20	
"	9	Mount Helena.	8	+ 528.95	− 535.54	532.05	17	
"	9	Ross Mountain.		− 120.12				
MOUNT DIABLO.	8	Mount Helena.	8	+ 144.66	− 149.98	147.32	16	
"	8	Round Top.	16	+ 1965.2	− 1993.7	1984.2	24	
"	6	Marysville Butte.		− 517.5				
"	6	Mount Lola.	10	+ 1563.3	− 1606.4	1590.2	16	
"	3	Pine Hill.		− 548.1				
"	9	Ross Mountain.		− 649.0				
MOUNT HELENA.	4	Mount Lola.	10	+ 1501.0	− 1472.8	1480.9	14	
"	8	Marysville Butte.		− 679.46				
"	9	Round Top.	7	+ 1856.3	− 1821.7	1841.2	16	
"	6	Pine Hill.		− 662.9				
MOUNT LOLA.	11	Round Top.	19	+ 373.42	− 381.63	378.62	30	
"	10	Pine Hill.		− 2168.6				
"	9	Marysville Butte.		− 2149.8				
ROUND TOP.	14	Jackson Butte.	14	− 2460.6	+ 2457.9	2459.3	28	
"	18	Pine Hill.		− 2543.8				
"	9	Marysville Butte.		− 2517.9				
JACKSON BUTTE.	7	Pine Hill.		− 81.23				

The above table contains sixty-two differences of height, three of which were previously given by spirit leveling. For the difference in height between the termini of the base, the computed difference falls short of the spirit-level result by $1^{m}.1$ and the observed ζ's apparently prove the refraction along this line to have been negative, *i. e.*, the ray of light was convex toward the earth's surface. This is due to the excessive heat of the ground* and the proximity of the ray thereto. In the lines from the base to Mount Diablo with zenith distances observed only at the base, we have differences of $6^{m}.1$ and of $0^{m}.3$, the distances being 72 and 89 kilometers. No further notice will be taken of the results by zenith distances of these three lines.

In the following adjustment by the method of least squares, the heights of the stations forming the connection of the base with a primary line had to be treated by themselves, for the reason that this part of the work only is complete, whereas the stations to the eastward of the base will be ultimately connected with the transcontinental line of spirit-levels at Mount Lola, at Round Top, and at Jackson Butte, for which points our present results are only of temporary use; the long lines between 188 and 229 kilometers will then disappear from the hypsometric work.

In general, when there is a choice of selection of the process of adjustment between "indirect observations" and "conditioned observations," the former is generally preferable as offering greater facilities for the computation of probable errors of the result.

ESTIMATE OF THE PROBABLE ERROR OF THE PRECEDING RESULTS $\triangle h$ AND DETERMINATION OF WEIGHTS FOR THEIR ADJUSTMENT.

Making use of the simple expression $\triangle h = s \cot \zeta + \frac{1-2m}{2\rho} s^2$ we have:

$$d.\triangle h = \left(\cot \zeta + \frac{s}{\rho}\right) ds - \frac{s}{\sin^2 \zeta} d\zeta - \frac{s^2}{\rho} dm$$

And putting $ds = 0$ and $\sin^2 \zeta = 1$, also let e_ζ = probable error of ζ and e_m = probable error of m, then the square of probable error e_h of a value $\triangle h$

$$e_h^2 = \left(s \text{ arc } 1'' \, e_\zeta\right)^2 + \left(\frac{s^2}{\rho} e\right)^2$$

And the weight=

$$p_h = \frac{1}{e_h^2}$$

e_ζ is here expressed in seconds; its numerical value was found from the table of measured zenith distances of 57 stations on 488 days, between 9 occupied stations; the resulting probable error of a measured zenith distance ζ on any *single day* was found $= \pm 11''.4$, hence our value e_ζ for the mean of n days.

$$e_\zeta = \frac{11''.4}{\sqrt{n}}$$

The amount of $11''.4$ is chiefly made up of variations in the refraction, the actual *observing* error being very much smaller, perhaps not exceeding $\pm 2''$. The numerical value of e_m had to be estimated, and the value $e_m = \pm 0.0020$ was adopted as a close approximation.

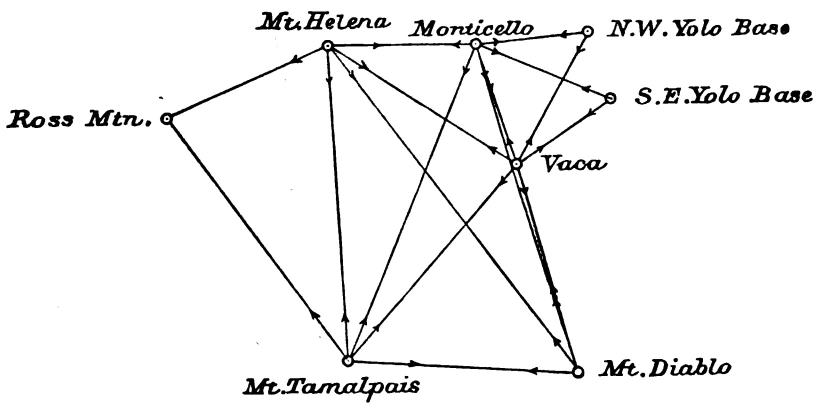
The *a priori* probable error for each of the 14 results computed by the above formula is given in the table of results submitted to adjustment, together with the weights of each determination depending thereon.

ADJUSTMENT OF THE MEASURED DIFFERENCES OF HEIGHTS OF STATIONS FORMING THE CONNECTION OF THE YOLO BASE WITH THE PRINCIPAL TRIANGULATION BY APPLICATION OF THE METHOD OF LEAST SQUARES BY THE PROCESS REFERRING TO INDIRECT OBSERVATIONS.

This adjustment comprises the heights of stations Monticello, Vaca, Mount Tamalpais, and Mount Helena, as depending on zenith distances and the absolute heights by spirit-level of South-

* On two days the temperature of the air during observations rose above 100° Fah.

east Yolo Base, Northwest Yolo Base, Mount Diablo, and Ross Mountain. These stations are shown in their relative position in the accompanying figure, and the measured zenith distances are



indicated by arrows. It is important to bear in mind that each difference of height depends on a *double* determination, except the measures on Ross Mountain. The longest distance, *i. e.*, Mount Helena to Mount Diablo, is 108 kilometers, or 67 statute miles.

We have given by spirit level:

			m. m.
Height, above average sea-level, of	Southeast Yolo Base	$H_1=$	21.66 ± 0.35
	Northwest Yolo Base	$H_2=$	46.66 ± 0.35
	Mount Diablo	$H_3=$	1173.10 ± 0.20
	Ross Mountain	$H_8=$	672.23 ± 0.15

And from table p. 399 by zenith distances:

No.	Stations. h	h_1	Days n.	Difference of height $\Delta h=h_1-h$	Probable error r_h	Weight.
				m.	m.	
1	Southeast Yolo Base	and Vaca.	18	708.57	±0.40	2.9
2	Southeast Yolo Base	and Monticello.	16	910.48	0.54	1.5
3	Northwest Yolo Base	and Vaca.	20	683.62	0.53	1.6
4	Northwest Yolo Base	and Monticello.	17	885.82	0.39	3.0
5	Monticello	and Mount Helena.	15	390.54	0.58	1.3
6	Monticello	and Mount Diablo.	15	240.33	2.06	0.11
7	Monticello	and Mount Tamalpais.	13	−138.48	2.09	0.10
8	Monticello	and Vaca.	15	−201.16	0.48	1.9
9	Vaca	and Mount Diablo.	18	445.11	0.95	0.50
10	Vaca	and Mount Tamalpais.	15	59.69	1.28	0.28
11	Vaca	and Mount Helena.	20	591.41	0.96	0.50
12	Mount Tamalpais	and Mount Diablo.	20	386.12	1.01	0.44
13	Mount Tamalpais	and Mount Helena.	17	532.05	1.76	0.15
14	Mount Tamalpais	and Ross Mountain.	9	−120.12	2.95	0.05
15	Mount Helena	and Mount Diablo.	16	−147.32	2.78	0.06
16	Mount Helena	and Ross Mountain.	9	−649.00	1.17	0.33

There being four unknown heights to be determined, we make the following assumptions:

			m.
Heights of	Southeast Yolo Base	$H_1=$	21.66
	Northwest Yolo Base	$H_2=$	46.66
	Mount Diablo	$H_3=$	1173.10
	Vaca	$H_4=$	$730+x_4$
	Monticello	$H_5=$	$932+x_5$
	Mount Tamalpais	$H_6=$	$790+x_6$
	Mount Helena	$H_7=$	$1322+x_7$
	Ross Mountain	$H_8=$	672.23

The equations resulting directly from the observations are of the form

$$\delta_1 = a_1 x_1 + b_1 x_2 + c_1 x_3 + \ \dots\ + l_1$$

and x_1 x_2 x_3 x_4 . . . are the corrections to the assumed values (H_1) (H_2) (H_3) (H_4) . . . . .

To obtain more convenient numbers for the weights, those of the preceding table were multiplied by 10 and the nearest whole numbers were kept.

δ	a	b	c	d	l	p
1	+1	......	......	......	−0.23	29
2	......	+1	......	......	−0.14	15
3	+1	......	......	......	−0.28	16
4	......	+1	......	......	−0.48	30
5	......	−1	......	+1	−0.54	13
6	......	−1	......	......	+0.77	1
7	......	−1	+1	......	−3.52	1
8	+1	−1	......	......	−0.84	19
9	−1	......	......	......	−2.01	5
10	−1	......	+1	......	+0.31	3
11	−1	......	......	......	+0.59	5
12	......	......	−1	......	−3.02	4
13	......	......	−1	+1	−0.05	2
14	......	......	−1	......	+2 35	1
15	......	......	......	−1	−1.58	1
16	......	......	......	−1	−0.77	3

Normal equations.

$$\begin{aligned}
0 &= 77\,x_4 - 19\,x_5 - 3\,x_6 - 5\,x_7 - 20.94\\
0 &= -19\,x_4 + 79\,x_5 - x_6 - 13\,x_7 + 9.23\\
0 &= -3\,x_4 - x_5 + 11\,x_6 - 2\,x_7 + 7.24\\
0 &= -5\,x_4 - 13\,x_5 - 2\,x_6 + 24\,x_7 - 0.28
\end{aligned}$$

Solution.

Solution	Residuals.
$x_4 = +0.2278$	+.017
$x_5 = -0.0749$	−.012
$x_6 = -0.608$	+.004
$x_7 = -0.0307$	+.033

Adjusted heights.

$H_4 = 730^m.228$
$H_5 = 931^m.925$
$H_6 = 789^m.392$
$H_7 = 1321^m.969$

Substituting into the observation-equations we form

$$\begin{array}{llll}
\delta_1 = \ .00^m & \delta_2 = -\ .21^m & \delta_3 = -\ .05^m & \delta_4 = -\ .55^m\\
\delta_5 = -\ .50 & \delta_6 = +\ .84 & \delta_7 = -\ 4.05 & \delta_8 = -\ .54\\
\delta_9 = -\ 2.24 & \delta_{10} = -\ .53 & \delta_{11} = +\ .33 & \delta_{12} = -\ 2.41\\
\delta_{13} = +\ .53 & \delta_{14} = +\ 2.96 & \delta_{15} = -\ 1.55 & \delta_{16} = -\ .74
\end{array}$$

and $\Sigma p\,\delta\,\delta = 98.74$

Mean error of an observation of unit weight $\sqrt{\dfrac{98.74}{16-4}} = \pm\ 2^m.87$

Probable error of an observation of unit weight $.674\sqrt{\dfrac{98.74}{16-4}} = \pm\ 1.94$

Thus for a weight 15 assigned to an observation the corresponding probable error would be

$$\frac{1^m.94}{\sqrt{15}} = \pm\ 0^m.50$$

The *a priori* assigned value in this case was $\pm\ 0^m.54$, showing a satisfactory accord. The corresponding distance is nearly 39 kilometers.

For the determination of the weights of x_i we leave the numerical terms in the normal equations symbolic, thus:

$$\begin{aligned}
N_4 &= +\ 77\,x_4 - 19\,x_5 - 3\,x_6 - 5\,x_7\\
N_5 &= -\ 19\,x_4 + 79\,x_5 - x_6 - 13\,x_7\\
N_6 &= -\ 3\,x_4 - x_5 + 11\,x_6 - 2\,x_7\\
N_7 &= -\ 5\,x_4 - 13\,x_5 - 2\,x_6 + 24\,x_7
\end{aligned}$$

Solving we find

$$x_4 = + .0147\ N_4 + .0046\ N_5 + .0055\ N_6 + .0060\ N_7$$
$$x_5 = + .0046\ N_4 + .0154\ N_5 + .0045\ N_6 + .0097\ N_7$$
$$x_6 = + .0055\ N_4 + .0045\ N_5 + .0949\ N_6 + .0115\ N_7$$
$$x_7 = + .0060\ N_4 + .0097\ N_5 + .0115\ N_6 + .0491\ N_7$$

the weight x_1 is the reciprocal of the diagonal factor of N_1 in the above equations, thus

$$\text{weight } p_4 \text{ of } x_4 = \frac{1}{.0147}$$

$$\text{weight } p_5 \text{ of } x_5 = \frac{1}{.0154}$$

$$\text{weight } p_6 \text{ of } x_6 = \frac{1}{.0949}$$

$$\text{weight } p_7 \text{ of } x_7 = \frac{1}{.0491}$$

The probable error of an adjusted value r_1 is given by

$$r = .674\sqrt{\frac{[p\delta\delta]}{(\nu-\mu)p}}$$

where ν = number of observations and μ = number of conditions between them.

$$\text{Probable error of } x_4 = 1.94\sqrt{.0147} = \pm \overset{m.}{0.235}$$
$$x_5 = 1.94\sqrt{.0154} = 0.240$$
$$x_6 = 1.94\sqrt{.0949} = 0.596$$
$$x_7 = 1.94\sqrt{.0491} = 0.429$$

and the resulting heights become:

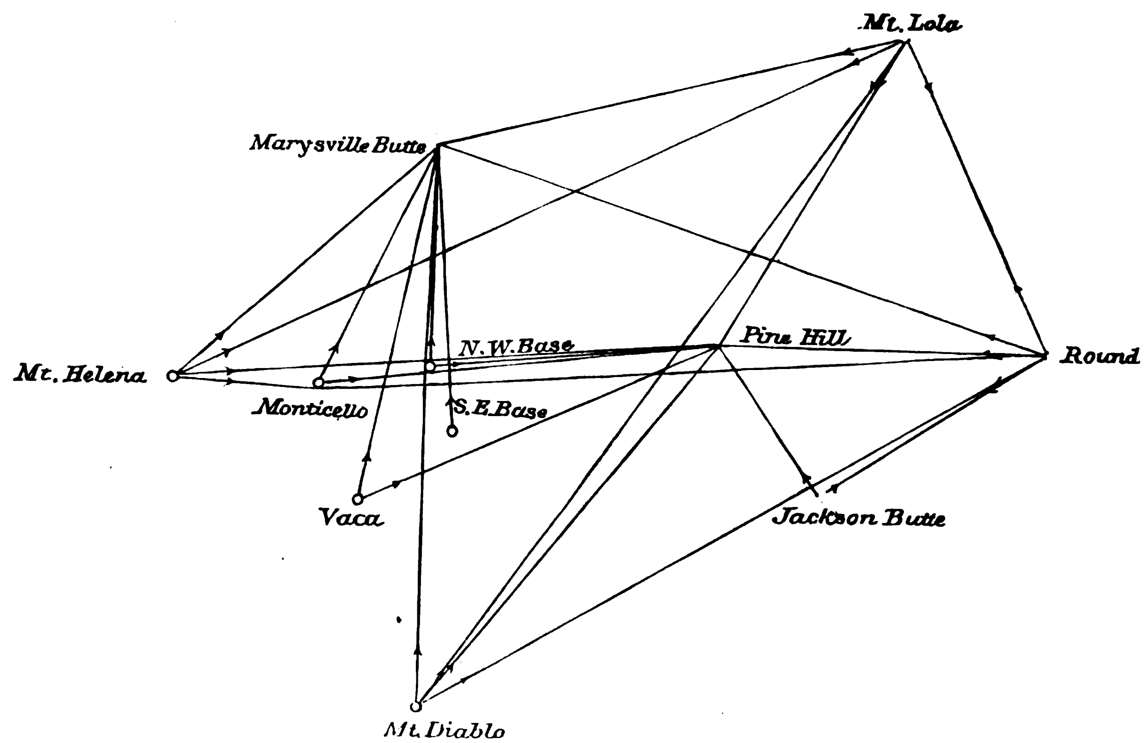
Heights of Vaca,	730.228	±0.235 m.
Monticello,	931.925	0.240
Mount Tamalpais,	789.392	0.596
Mount Helena	1321.969	0.429

In conclusion of this paragraph, it may be stated that under the hypothesis of equal refraction at the upper and lower stations, and by treating the reciprocal non-simultaneous measures of ζ as if they had been simultaneous, there results from 19 cases the average coefficient of refraction $m = 0.0725$, after having thrown out one value, *i. e.*, that at the base, which gives a negative value, as already stated; the individual values vary between 0.058 and 0.078 On the other hand, the new method followed gave an average value, $m = 0.0742$, resulting from 60 values, and varying between the extremes 0.061 and 0.085 The average value may be useful for other height-determinations in this part of California.

The results given in the remaining part of this paper are only for temporary use until the field operations, and in particular the spirit levelings, shall have been completed. We must, therefore, be content for the present with a rough determination of the heights of Mount Lola and Round Top stations, belonging to the Davidson Quadrilaterals.

No least square adjustment will be attempted, but the separate individual results for difference of height, already given, and which enter into combination, will be treated by the method of the weighted mean, as shown below.

The accompanying diagram indicates the stations involved; those surrounded by a ring have their heights fixed, and the heights of the other five stations depend on these, as indicated by the arrows, which represent measured zenith distances. The longest distance is from Mount Helena to Round Top, 229 kilometers in length; the scale is the same as in the diagram of the preceding part.



The computation of difference of heights, their probable errors and weights, were made precisely as in the preceding part. In the following recapitulation of results the distances expressed in kilometers have been added. The probable errors given depend on the assumption of e_{ζ} and e_m as before, and the ordinary combination weights were multiplied by 100 for convenience sake. The least weight admitted is 0.5

Recapitulation of measures.

No.	Stations occupied and observed. h	h_1	Distance s.	Days n.	Difference of height $h_1 - h$.	Probable error h	Relative weight 100 p.
			Kilometers.		*m.*	*m.*	
1	Southeast Yolo Base	and Marysville Butte.	75.3	6	+ 617.17	± 1.9	12
2	Northwest Yolo Base	and Pine Hill.	75.7	8	+ 578.7	1.8	14
3	Northwest Yolo Base	and Marysville Butte.	58.6	11	+ 599.18	1.1	36
4	Monticello	and Marysville Butte.	68.2	8	− 286.68	1.5	19
5	Monticello	and Pine Hill.	104.6	7	− 291.1	3.0	5
6	Vaca	and Marysville Butte.	95.1	8	− 92.96	2.5	7
7	Vaca	and Pine Hill.	102.7	5	− 90.9	3.2	4
8	Mount Diablo	and Marysville Butte.	147.2	6	− 517.5	5.5	2
9	Mount Diablo	and Pine Hill.	123.2	3	− 548.1	4.7	2
10	Mount Diablo	and Round Top.	188.6	24	+1984.2	7.7	1
11	Mount Diablo	and Mount Lola.	218.7	16	+1590.2	10.5	0.5
12	Mount Helena	and Mount Lola.	213.9	14	+1480.9	10.0	0.5
13	Mount Helena	and Marysville Butte.	92.3	8	− 679.5	2.4	8
14	Mount Helena	and Round Top.	229.1	16	+1841.2	11.4	0.5
15	Mount Helena	and Pine Hill.	143.0	6	− 662.9	5.2	2
16	Mount Lola	and Round Top.	91.0	30	+ 378.6	1.9	12
17	Mount Lola	and Pine Hill.	95.9	10	−2168.6	2.5	8
18	Mount Lola	and Marysville Butte.	128.0	9	−2149.8	4.0	3
19	Round Top	and Jackson Butte.	72.4	28	−2459.3	1.3	27
20	Round Top	and Pine Hill.	86.3	18	−2543.8	1.9	13
21	Round Top	and Marysville Butte.	168.9	9	−2517.9	6.6	1
22	Jackson Butte	and Pine Hill.	48.2	7	− 81.2	1.0	44

For the combination of these differences of heights we follow the principle of selecting for the first station, that one whose height is most accurately determined from surrounding stations already known. The accuracy depends on the number of separate determinations, as well as on the distances from the stations of known heights. The same principle is followed for the next station, and so on. Accordingly we have the following combinations:

	m. m. m.	Weight.
Height of Marysville Butte from		
Southeast Yolo Base	21.66 + 617.17 = 638.83	12
Northwest Yolo Base	46.66 + 599.18 = 645.84	36
Monticello	931.92 − 286.68 = 645.24	19
Vaca	730.23 − 92.96 = 637.27	7
Mount Helena	1322.0 − 679.5 = 642.5	8
Mount Diablo	1173.1 − 517.5 = 655.6	2
	Weighted mean 643.9	84
Height of Pine Hill from		
Northwest Yolo Base	46.7 + 578.7 = 625.4	14
Monticello	931.9 − 291.1 = 640.8	5
Vaca	730.2 − 90.9 = 639.3	4
Mount Helena	1322.0 − 662.9 = 659.1	2
Mount Diablo	1173.1 − 548.1 = 625.0	2
	Weighted mean 632.8	27
Height of Jackson Butte from		
Pine Hill	632.8 + 81.2 = 714.0	44
Height of Round Top from		
Mount Diablo	1173.1 + 1984.2 = 3157.3	1
Mount Helena	1322.0 + 1841.2 = 3163.2	0.5
Pine Hill	632.8 + 2543.8 = 3176.6	13
Marysville Butte	643.9 + 2517.9 = 3161.8	1
Jackson Butte	714.0 + 2450.3 = 3173.3	27
	Weighted mean 3173.5	42.5
Height of Mount Lola from		
Pine Hill	632.8 + 2168.6 = 2801.4	8
Marysville Butte	643.9 + 2149.8 = 2793.7	3
Round Top	3173.5 − 378.6 = 2794.9	12
Mount Helena	1322.0 + 1480.9 = 2802.9	0.5
Mount Diablo	1173.1 + 1590.2 = 2763.3	0.5
	Weighted mean 2796.4	24

It will be noticed that in every case where Mount Diablo enters the resulting height represents an extreme values from which we may infer that the disturbing cause would seem to be local and may be sought in the peculiar position of the mountain with respect to the sea and to the valley.

As stated, Round Top and Mount Lola will ultimately be connected by spirit level brought up directly from Fort Point or Saucelito in the Golden Gate.

For temporary use we have the approximate values:

		m. m.
Heights of	Marysville Butte	643.9 ± 1.1
	Pine Hill	632.8 ± 3.4
	Jackson Butte	714.0
	Round Top	3173.5 ± 1.3
	Mount Lola	2796.4 ± 2.0

where the rough value for the probable error is derived, as usual, from

$$.674\sqrt{\frac{[pvv]}{[p](n-1)}}$$

n being the number of separate determinations.

CHAS. A. SCHOTT,
Assistant, in charge Comp. Division.

APPENDIX No. 11.

LONGITUDES DEDUCED IN THE COAST AND GEODETIC SURVEY FROM DETERMINATIONS BY MEANS OF THE ELECTRIC TELEGRAPH BETWEEN THE YEARS 1846 AND 1885. SECOND ADJUSTMENT.

By CHARLES A. SCHOTT, Assistant.

PREFATORY NOTE.

In this report on the principles adopted and the results obtained in a second adjustment of the longitude system of the Coast and Geodetic Survey, Assistant Schott has presented a comprehensive discussion of all measures for longitude by the electric telegraph hitherto obtained on the Survey. He has included in this discussion the longitude of Detroit, Mich., the fundamental longitude station of the United States Lake Survey, and has given in his table of results a value derived for the longitude of Ogden, Utah, this being the principal point of reference for the longitudes obtained in the United States Geographical Surveys west of the one hundredth meridian.

For the computation of the probable error of results, he has given the leading steps (formulæ and numbers), since the treatment of the probable error of a function of adjusted measures, involving conditional equations and the use of correlates, has not hitherto been shown in any application on the Survey.

It will be seen from the report that the results of the American system of telegraphic longitudes compare quite favorably in accuracy with those of the European system, the average probable error of a longitude determination for the latter system as deduced by Dr. Bruhns in his recent discussion differing not greatly from the average probable error of a single determination as found by Mr. Schott.

J. E. HILGARD,
Superintendent.

COAST AND GEODETIC SURVEY OFFICE,
Computing Division, November 29, 1884.

DEAR SIR: Since the publication, in 1880,* of the results of a first adjustment of telegraphic longitudes determined by the Coast and Geodetic Survey, the progress made in this branch of geodesy has been considerable, not only in the field work, but also in the office computations. This may be seen at a glance by the following comparison of the state of the work at that time and at present: Total number of differences of longitude measured, in 1880, 127, at present 158; of the former number 30 required a second or check computation, whereas the final values of all longitudes, to date, with the exception of two for which further data are wanted, are now presented. In the first adjustment of the system of longitudes there were 25 points between which 10 conditions had to be satisfied, in the second adjustment the number of connected principal points has increased to 33, and the number of conditions between them to 21. The change in the ratio of the number of points to the number of conditions indicates great increase in strength of the

* Appendix No. 6, Coast and Geodetic Survey Report for 1880.

system. Referring to the diagrams of the two reports, the westernmost station was New Orlea La., in 1880; in the present papers it is Omaha, Nebr., and it may be expected that in the n discussion the checks will reach the Pacific coast. The appended diagram, plate No. 21, whicl intended to show the connections only, has been made more definite by the addition to each l of the year of determination. The geographical positions of all the longitude stations and th connections are shown on the accompanying chart No. 19. As a matter of interest and for the ri understanding of the earlier results of the survey, I have thought it desirable to repeat here a b historical note taken from my first discussion.

In the autumn of 1845 Superintendent A. D. Bache issued instructions to Sears C. Walk Assistant, for the development of the method of determining geographical longitudes by mean the electro-magnetic telegraph.

The first published notice by the Superintendent of the use of this method for geodetic p poses is found in Coast Survey Report for 1846, on p. 32, and in its Appendix No. 11, p. 72. T first difference of longitude, actually measured and comparing in accuracy with other astronomi methods *then* in use, was on October 10, 1846, between Washington and Philadelphia. The operation of the Superintendent of the United States Naval Observatory and of the directo the High School observatory having been secured, the Survey built short telegraphic lines conn ing the respective observatories with the telegraph offices of the two cities; the resulting ference of longitude is given as No. 1 in our general table. The field and office work connec with the telegraphic longitudes of the Coast Survey was under the special charge of Assist Walker, by whom the method was speedily developed into one of great accuracy, and at o superseded the older methods in all cases where electric connection could be had. Assist Walker continued in charge for seven years to the close of 1852, when in consequence of his illne Dr. Benjamin A. Gould was appointed Assistant by the Superintendent in December, 1852, to t charge of the telegraphic-longitude work; Dr. Gould continued* in this duty till 1867, when he resig his position in the Survey. From 1867 to 1874, inclusive, Assistant G. W. Dean was principa in charge of the work under the immediate instructions of the Superintendent. After the y 1874 no special appointment was deemed necessary, as the method had long taken its place amo other known geodetic operations. In September, 1878, however, Superintendent C. P. Patter directed the computations for telegraphic longitudes to be made in the Computing Division of Office as a part of its regular duty, but still requiring a rough field computation from the observ

The revisions of computations and the new computations of longitudes indicated in my rep of June, 1880, have since been carried out, and the new determinations made after 1880 and up the present time have all been computed. Additional attention was paid to the relative weig of individual results at a station so far as they depend on the variability in the rate of the ch nometer in the interval between the transit epoch and that of the time of exchange of sign with the opposite station, yet the effect of small changes in weights on the final result is in m cases inappreciable. With regard to field-practice, the superiority of results by the substituti of *arbitrary* break-signals in the place of *automatic* breaks for the exchange between stations been fully recognized. During exchanges the chronograph is run at double speed, allowing nearest hundredth of a second of time to be readily measured off. The modern use of qui acting electro-magnets and the equalization of the strength of the current contribute to grea increased accuracy. As far as practicable, the same stars are observed at both stations.

EXPLANATORY REMARKS TO THE FOLLOWING TABLE OF RESULTS.

The westernmost of the two stations is always given first, thus avoiding all ambiguity, differences of longitude having the same sign. The reference-mark at fixed observatories is g erally the center of dome or other recognized local meridian; when the transit of the station referred to it is indicated by Tr't. Two numbers in the column "No. of days of observati indicate the number of days before and after the observers exchanged places; when but number is given no exchange took place, and the differential personal equation was, in gener ascertained before or after the longitude determination proper.

* He died in February, 1853.

The station Detroit, Mich., which had served as the fundamental longitude station of the United States Lake Survey, † as well as the station Ogden, Utah, which had served in like capacity for the United States Geographical surveys west of the 100th meridian ‡ were introduced in our table (though without running numbers) in consequence of their geographical importance.

TABLE I.—*General table of results for differences of longitude of stations determined by the United States Coast and Geodetic Survey by means of the electric telegraph, between the years 1846 and 1884 (July).*

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
*1	Washington, United States Naval Observatory, D. C.	Dome.	S. C. Walker, M. F. Maury, J. J. Almy.	1846	October	1	0 07 34.14	±0.50
	Philadelphia, Central (old) high school, Pa.	Mer. C.	E. O. Kendall.					
2	Washington, United States Naval Observatory, D. C.	Dome.	R. Keith [M. F. Maury].	1847	July, Aug.	5	0 07 33.61	±0.10
	Philadelphia, Central (old) high school, Pa.	Mer. C.	E. O. Kendall, — Reynolds, A. Mason.					
3	Philadelphia, Central (old) high school, Pa.	Mer. C.	Do.	1847	Do.	8	0 04 29.89	±0.09
	Jersey City, Loomis' observatory, N. J.	Tr't.	E. Loomis.					
4	Washington, United States Naval Observatory, D. C.	Dome.	R. Keith [M. F. Maury].	1847	Do.	2	0 12 03.50	±0.23
	Jersey City, Loomis' observatory, N. J.	Tr't.	E. Loomis.					
5	New York, Rutherfurd's observatory, N. Y.	Tr't.	E. Loomis, S. C. Walker.	1848	Do.	5	0 11 26.044	±0.042
	Cambridge, Harvard College observatory, Mass.	Dome.	W. C. Bond, Joseph Bond.					
6	Cincinnati, Mount Adams observatory, Ohio.	Tr't.	O. M. Mitchel, — Twitchell, M. Yarnall, — Trask, S. C. Walker, L. F. Pourtales.	1848	October	6	0 37 20.586	±0.060
	Philadelphia, Central (old) high school, Pa.	Mer. C.	E. O. Kendall, A. Mason, — Reynolds.					
7	Hudson, Western Reserve College, Ohio.	Tr't C.	E. Loomis.	1849	August	3	0 25 05.696	±0.045
	Philadelphia, Central (old) high school, Pa.	Mer. C.	E. O. Kendall, A. Mason.					
*8	Washington, Seaton station, D. C.	Tr't.	L. F. Pourtales, J. C. Langton.	1849	Do.	1	0 07 20.81	±0.20
	Philadelphia, Central (old) high school, Pa.	Mer. C.	E. O. Kendall, A. Mason, — Reynolds.					
*9	Charleston, Gibbes' observatory, S. C.	Tr't.	L. R. Gibbes.	1850	February	1	0 11 45.27	±0.10
	Washington, Seaton station, D. C.	Tr't.	L. F. Pourtales, J. C. Langton.					
*10	Savannah, Exchange station, Ga.	Tr't.	C. O. Boutelle.	1851	Feb., Mar.	4	0 04 37.15	±0.11
	Charleston, Gibbes' observatory, S. C.	Tr't.	L. R. Gibbes, J. C. Langton.					
11	Cambridge, Harvard College observatory, Mass.	Dome.	W. C. Bond.	1851	Nov., Dec.	4	0 09 23.080	±0.043
	Bangor, Thomas Hill station, Me.	Tr't.	S. C. Walker, L. F. Pourtales, J. C. Langton.					
12	Cambridge, Harvard College observatory, Mass.	Dome.	W. C. Bond.	1851	December	1	0 30 09.44	±0.13
	Halifax, naval yard observatory, N. S.	Tr't.	Capt. Shortland, R. N.					
13	Bangor, Thomas Hill station, Me.	Tr't.	S. C. Walker, L. F. Pourtales, J. C. Langton.	1851	Do.	4	0 20 46.557	±0.067
	Halifax naval yard observatory, N. S.	Tr't.	Capt. Shortland, R. N.					
14	Petersburg, Roslyn station, Va.	Tr't.	A. D. Bache, G. W. Dean.	1852	July, Aug.	6	0 01 35.591	±0.022
	Washington, Seaton station, D. C.	Tr't.	L. F. Pourtales.					
15	Raleigh, State-House grounds, N. C.	Tr't.	B. A. Gould.	1853	April	4	0 06 32.873	±0.044
	Washington, Seaton station, D. C.	Tr't.	L. F. Pourtales.					

(1) This result is now only of historical interest as the first one where a numerical measure was attempted.

(8) No use is made of this weak determination. Combined with No. 1 it would give for Washington Naval Observatory and Seaton $\Delta\lambda = 12^s.80 \pm 0^s.22$ when the correct value is $12^s.62$

(9) A defective value; only one night's observation; personal equation supposed too small to be considered; a preliminary adjustment showed the result to be in error about one-quarter of a second; it has consequently been abandoned.

(10) An unreliable determination; no observations for personal equation; a preleminary adjustment indicated the result, like the preceding one, to be nearly one-quarter of a second too great; it has been rejected.

† Professional Papers Corps of Engineers, U. S. A., No. 24. Report upon the primary triangulation of the United States Lake Survey, by Lieut. Col. C. B. Comstock. Washington, 1882.

‡ United States Geographical Surveys west of the 100th meridian, in charge of Lieut. G. M. Wheeler, Corps of Engineers, U. S. A. Vol. II: Washington, 1877.

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
*16	Charleston, Gibbes' observatory, S. C.	Tr't.	L. R. Gibbes.	1853	April, May	3	0 05 12.08	±0.15
	Raleigh, State-House grounds, N. C.	Tr't.	B. A. Gould.					
17	Columbia, Capitol Square, S. C.	Tr't.	B. A. Gould, G. W. Dean.	1854	Jan., Feb., Mar.	2+2	0 09 35.862	±0.041
	Raleigh, State-House grounds, N. C	Tr't.	G. W. Dean, B. A. Gould.					
18	Wilmington, De Rosset station, N. C.	Tr't.	G. W. Dean, A. D. Bache, L. F. Pourtales.	1854	May, June	3+4	0 02 11.340	±0.033
	Petersburg, Roslyn station, Va.	Tr't.	B. A. Gould, L. F. Pourtales, G. W. Dean.					
19	Macon, Academy Square, Ga.	Tr't.	G. W. Dean, E. Goodfellow.	1855	Jan., Feb., Mar.	3+4	0 10 22.250	±0.051
	Columbia, Capitol Square, S. C.	Tr't.	E. Goodfellow, G. W. Dean.					
20	Columbia, Capitol Square, S. C.	Tr't.	G. W. Dean, E. Goodfellow.	1856	Jan., Feb.	4+2	0 12 21.731	±0.028
	Wilmington, De Rosset station, N. C.	Tr't.	E. Goodfellow, G. W. Dean.					
21	Montgomery, Capitol grounds, Ala.	Tr't.	G. W. Dean, A. D. Bache, E. Goodfellow.	1856	Mar., April	4+4	0 10 41.570	±0.015
	Macon, Academy Square, Ga.	Tr't.	E. Goodfellow, G. W. Dean.					
22	Lower Peach Tree, Ala.	Tr't.	Do.	1857	April	4+4	0 04 58.789	±0.016
	Montgomery, Capitol grounds, Ala.	Tr't.	G. W. Dean, E. Goodfellow.					
23	Mobile, Public Square, Ala.	Tr't.	E. Goodfellow, G. W. Dean.	1857	May, June	4+3	0 01 59.768	±0.016
	Lower Peach Tree, Ala.	Tr't.	G. W. Dean, E. Goodfellow.					
24	Bangor, Thomas Hill station, Me.	Tr't.	A. D. Bache, E. Goodfellow, G. W. Dean.	1857	Sept., Oct.	4+3	0 06 00.316	±0.015
	Calais, Academy grounds, Me.	Tr't.	G. W. Dean, E. Goodfellow.					
25	Calais, Academy grounds, Me.	Tr't.	E. Goodfellow.	1857	October	1	0 02 34.73	±0.5
	Fredericton, Toldervy's observatory, N. B.	Tr't.	Dr. J. Toldervy, Dr. W. B. Jack.					
*26	New Orleans, Basin street station, La.	Tr't.	E. Goodfellow.	1858	Jan., Feb.	3	0 03 17.74	±0.3
	Head of Passes, Mississippi delta, La.	Tr't.	J. G. Oltmanns [F. H. Gerdes].					
*27	New Orleans, Basin street station, La.	Tr't.	E. Goodfellow, G. W. Dean.	1858	Jan., Feb., Mar., Apr.	6+3	0 08 07.147	±0.022
	Mobile, Public Square, Ala.	Tr't.	G. W. Dean, A. T. Mosman, E. Goodfellow.					
28	New York, Rutherfurd's observatory, N. Y.	Tr't.	E. Goodfellow, G. W. Dean.	1858	May, June	3+3	0 00 57.400	±0.012
	Albany, Dudley observatory grounds, N. Y.	Dome.	G. W. Dean, E. Goodfellow.					
29	Eufaula, Forsyth street station, Ala.	Tr't.	E. Goodfellow, G. W. Dean.	1860	Feb., Mar.	2+3	0 00 36.671	±0.010
	Apalachicola, Fla.	Tr't.	G. W. Dean, E. Goodfellow.					
30	Eufaula, Forsyth street station, Ala.	Tr't.	Do.	1860	April, May	3+2	0 06 02.986	±0.031
	Macon, Academy Square, Ga.	Tr't.	E. Goodfellow, G. W. Dean.					
31	Mobile, Public Square, Ala.	Tr't.	Do.	1861	Jan., Feb.	3+2	0 03 20.316	±0.022
	Pensacola, Barkley Point, Fla.	Tr't.	G. W. Dean, E. Goodfellow.					
32 to 41	Clarksburg, Academy station, W. Va.	V. Cir.	A. T. Mosman.	1863-4	Dec., Jan.	2	0 13 09.43	±0.5‡
	Grafton, station near railroad, W. Va.	V. Cir.	Do.	1864	January	1	0 11 54.68	
	Cameron, station near church, W. Va.	V. Cir.	Do.	1864	Do.	1	0 14 05.46	
	Wheeling, near river, W. Va.	V. Cir.	Do.	1864	Do.	2	0 14 42.40	
	Parkersburg, Courtland street, W. Va.	V. Cir.	Do.	1864	Do.	2	0 18 04.68	
	Point Pleasant, near river, W. Va.	V. Cir.	Do.	1864	February	1	0 20 22.98	
	South Point, station near brick church, Ohio.	V. Cir.	Do.	1864	Do.	2	0 22 09.70	
	Gauley Bridge, west side of river, W. Va.	V. Cir.	Do.	1864	Do.	1	0 16 39.79	
	Cumberland, Decarture street, Md.	V. Cir.	Do.	1864	March	2	0 06 49.57	
	Martinsburg, near railroad station, W. Va.	V. Cir.	Do.	1864	Do.	1	0 03 37.46	
	Washington, United States Naval Observatory, D. C.	Dome.	G. W. Dean, J. R. Eastman [J. M. Gilliss].					
42	Heart's Content, Trinity Bay, N. F.	Tr't.	G. W. Dean, E. Goodfellow.	1866	Oct., Nov.	5	2 51 56.356	±0.029
	Foilhommerum, Valentia Island, Ireland.	Tr't.	B. A. Gould, A. T. Mosman.					

(16) A new station was established at Charleston, on Citadel Square, in 1880. It is 5''.94 or 0s.396 *east* of the Gibbes' observatory transit, hence Δ λ Charleston, Citadel Square, transit and Raleigh transit 5m 11s.68

(26) A subordinate determination made only for temporary use until the triangulation could be completed; now abandoned.

(27) A new station was established at New Orleans in 1880 in Lafayette Square. It is 12''.985 or 0s.866 *east* of the old station of 1858; hence Δ λ New Orleans Transit of 1880 and Mobile Transit 8m 06s.281

(‡) Estimated probable error of any one result.

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
43	Foilhommerum, Valentia Island, Ireland.	Tr't.	B. A. Gould, A. T. Mosman.	1866	November	2	0 41 33.336	±0.049
	Greenwich Observatory, England.	Tran.Cir.	Greenwich observers [G. B. Airy].					
44	Calais, Academy grounds, Me.	Tr't.	G. Davidson, C. O. Boutelle, S. C. Chandler.	1866	December	3	0 55 37.973	±0.066
	Heart's Content, Trinity Bay, N. F.	Tr't.	E. Goodfellow [G. W. Dean].					
45	Washington, Seaton Station, D. C.	Tr't.	G. W. Dean, E. Goodfellow.	1867	June	6	0 23 28.474	±0.023
	Cambridge, Harvard College observatory, Mass.	Dome.	J. Winlock, G. M. Searle.					
*46	Washington, United States Naval Observatory, D. C.	Dome.	S. Newcomb, A. Hall, C. Thirion [B. F. Sands],	1867	Do.	5	0 23 41.116	+0.031
	Cambridge, Harvard College observatory, Mass.	Dome.	J. Winlock, G. M. Searle.					
*47	Washington, United States Naval Observatory, D. C.	Dome.	S. Newcomb, A. Hall, C. Thirion [B. F. Sands].	1867	Do.	6	0 00 12.634	±0.015
	Washington, Seaton station, D. C.	Tr't.	G. W. Dean, E. Goodfellow.					
*48	Galveston, Public square, Tex.	Tr't.	E. Goodfellow.	1868	February	6	0 18 51.85	±0.037
	New Orleans, Basin street station, La.	Tr't.	G. W. Dean.					
*49	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.	1869	Do.	6	1 39 15.065	±0.023
	Cambridge, Harvard College observatory, Mass.	Dome.	J. Winlock, A. T. Mosman, F. Blake, jr.					
50	Salt Lake City, Temple block station, Utah.	Tr't.	G. W. Dean.	1869	Do.	11	1 03 49.111	±0.009
	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.					
51	San Francisco, Washington Square, Cal.	Tr't.	G. Davidson.	1869	Do.	6	1 45 52.307	±0.014
	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.					
52	San Francisco, Washington Square, Cal.	Tr't.	G. Davidson.	1869	Feb., Mar.	10	0 42 03.196	±0.011
	Salt Lake City, Temple block, Utah.	Tr't.	G. W. Dean.					
53	Salt Lake City, Temple block, Utah.	Tr't.	Do.	1869	Do.	8	2 43 04.177	±0.021
	Cambridge, Harvard College observatory, Mass.	Dome.	J. Winlock, A. T. Mosman, F. Blake, jr.					
54	San Francisco, Washington Square, Cal.	Tr't.	G. Davidson.	1869	Do.	9	3 25 07.372	±0.022
	Cambridge, Harvard College observatory, Mass.	Dome.	J. Winlock, A. T. Mosman, F. Blake, jr.					
*55	Allegheny, Allegheny observatory, Pa.	Dome.	S. P. Langley.	1869	March	5	0 35 31.88	±0.04
	Cambridge, Harvard College observatory, Mass.	Dome.	J. Winlock, A. T. Mosman, F. Blake, jr.					
56	Staunton, near Dr. Sears' house, Va.	Mer. T.	A. T. Mosman.	1869	April	1	0 08 04.93	?
	Washington, United States Naval Observatory, D. C.	Dome.	C. Thirion [B. F. Sands].					
	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.					
57 to 60	Mattoon, grounds of school-house, Ill.	Tr't.	E. P. Austin.	1869	April, May	4	0 30 13.54	±0.10
	Springfield, grounds new State House, Ill.	Tr't.	do.	1869	May, June	3	0 25 08.70	±0.11
	Burlington, Public Square, Iowa.	Tr't.	do.	1869	June	3	19 20.38	±0.10
	Des Moines, grounds of Court-House, Iowa.	Tr't.	do.	1869	July	3	0 09 16.96	±0.12
61	Bushnell, Union Pacific Railroad station, Nebr.	?	O. N. Chaffee.	1869	Do.	1	0 31 45.75	?
62	Julesburg, Union Pacific Railroad station, Colo.	?	do.	1869	Do.	1	0 25 39.38	?
	Omaha, Nebr.	Tr't.	E. Goodfellow.					

(46) The terminations Nos. 45 and 46 are not quite independent, four of the dates in No. 46 occurring also in No. 45. See new determination n 1872 further on.

(47) Result not entirely independent of Nos. 45 and 46; only one independent day included.

(48) Referred to 1880 station at New Orleans the result becomes $18^m\ 52^s.72$ See note to No. 27.

(49) The results Nos. 49 to 54 are not quite independent. The six measures $\Delta\lambda$ between the four stations, Cambridge, Omaha, Salt Lake and a n Francisco, have the local transits of February 17, 18, 24, 25, and 27 in common. The three discrepancies thus arising were $-^s.017$, $+^s.011$ d $-^s.007$, which were removed by least square adjustment. The maximum correction is small, less than $0^s.01$ In consequence of this entanment Nos. 50, 51, 52 cannot be introduced in any general adjustment of longitudes in which Nos. 49, 53, 54 have already entered.

(55) See redetermination in 18[illegible] mean of the two measures, $35^m\ 31^s.94 \pm 0^s.04$

8) See redetermination of Springfield in 1882, from Saint Louis, Mo. and Omaha, Nebr.

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error
							h. m. s.	
63	Goodson, Lancaster Hill (near Bristol, Tenn.), Va.	Tr't.	R. D. Cutts, A. T. Mosman.	1869	July, August	3	0 20 32.84	±0
	Washington, United States Naval Observatory, D. C.	Dome.	Various observers [B. F. Sands].					
64	Cedar Falls, near railroad station, Iowa.	Tr't.	F. Blake, jr. [J. E. Hilgard].	1869	October	2	0 19 20.8	±0
	Chicago, Dearborn observatory, Ill.	?	T. H. Safford, A. N. Skinner.					
65	Cambridge, Harvard College observatory, Mass.	Dome.	J. Winlock, jr., E. P. Austin.	1869	December	8	0 01 50.191	±0
	Duxbury, station near cable office, Mass.	Tr't.	E. Goodfellow.	1870	Jan., Feb.			
*66	Duxbury, station near cable office, Mass.	Tr't.	do.	1870	Do.	11	4 24 43.276	±0
	Brest, station near St. Louis tower, France.	△	G. W. Dean.					
*67	Saint Louis, grounds Washington University, Mo.	Tr't.	W. Eimbeck.	1870	April	4	0 52 36.901	±0
	Washington, United States Naval Observatory, D. C.	Dome.	W. Harkness, E. Frisby [B. F. Sands].					
68	San Francisco, Washington Square, Cal.	Tr't.	G. Davidson.	1870	April, May	4	0 16 39.69	±0
	Los Angeles, Buenavista station, Cal.	Mer. T.	S. R. Throckmorton.					
*69	Burlington, Vt.	Tr't.	A. T. Mosman [G. W. Dean].	1870	Sept., Oct.	3	0 08 18.6	±0
	Cambridge, Harvard College observatory, Mass.	Dome.	E. P. Austin [J. Winlock].					
70	San Francisco, Washington Square, Cal.	Tr't.	S. R. Throckmorton.	1871	May	10	0 20 59.62	+0
	San Diego, Newtown, Cal.	Mer. T.	G. Davidson.					
†	Detroit, United States, Lake Survey observatory, Mich.	East Tr't.	O. B. Wheeler [C. B. Comstock].	1871	Do.	3	0 24 00.15	±0
	Washington, United States Naval Observatory, D. C.	Dome.	J. R. Eastman [B. F. Sands].					
*71	Chetopah, Kans.	Tr't.	R. Keith.	1871	July	3	0 19 35.56	±0
	Saint Louis, grounds Washington University, Mo.	Tr't.	W. Eimbeck.					
72	San Francisco, Washington Square, Cal.	Tr't.	G. Davidson.	1871	Sept., Oct.	13	0 00 18.42	±0
	Seattle, Duwamish Bay, Wash. Ter.	Mer. T.	S. R. Throckmorton.					
*73	Allegheny, Allegheny observatory, Pa.	Dome.	S. P. Langley.	1871	Do.	5	0 35 32.01	+0
	Cambridge, Harvard College observatory, Mass.	Dome.	H. Gannett [J. Winlock].					
74	Columbus, Capitol Square, Ohio.	Tr't.	G. W. Dean.	1871	Do.	6	0 47 27.713	±0
	Cambridge, Harvard College observatory, Mass.	Dome.	H. Gannett [J. Winlock].					
75	Columbus, Capitol Square, Ohio.	Tr't.	G. W. Dean.	1871	October	2	0 05 12.929	±0
	Cleveland, grounds Marine Hospital, Ohio.	Mer. T.	E. Goodfellow.					
76	Cleveland, grounds Marine Hospital, Ohio.	Mer. T.	Do.	1871	Do.	3	0 42 14.875	±0
	Cambridge, Harvard College observatory, Mass.	Dome.	H. Gannett [J. Winlock].					
77	Oakland, near eclipse station, Ky.	Tr't.	A. T. Mosman.	1871	November	4	1 00 30.23	±0
	Cambridge, Harvard College observatory, Mass.	Dome.	H. Gannett [J. Winlock].					
78	Shelbyville, college grounds, Ky.	Tr't.	A. T. Mosman [G. W. Dean].	1871	Nov., Dec.	5	0 56 22.05	±0
	Cambridge, Harvard College observatory, Mass.	Dome.	H. Gannett [J. Winlock].					
79	Falmouth, Colman's farm, Ky.	Mer. T.	E. Goodfellow.	1871	December	3	0 52 49.60	±0
	Cambridge, Harvard College observatory, Mass.	Dome.	H. Gannett [J. Winlock].					
80	Austin, public reservation, Tex.	Mer. T.	W. Eimbeck.	1872	April	3	1 10 53.86	±0
	Allegheny, Allegheny observatory, Pa.	Dome.	S. P. Langley.					
81	San Francisco, Washington Square, Cal.	Tr't.	G. Davidson.	1872	June	6	0 09 47.333	±0
	Verdi, East Base, Nev.	Mer. T.	S. R. Throckmorton.					

(66) Reduced to flag-staff or trigonometrical station on the Saint Louis tower, the transit being $0^s.409$ *west* of the tower. The difference of [lon]gitude referred to the tower station is $4^h\ 24^m\ 42^s.867 + 0^s.409 = 4^h\ 24^m\ 43^s.276$ as given in the table. See also note to No. 83.

(67) The new station established in 1881 is $0^s.125$ *west* of the old station, hence difference of longitude when referred to station of $0^h\ 52^m\ 37^s.026$

(69) A subordinate and temporary determination now abandoned, the trigonometrical connection having been made.

(†) Detroit, Mich., though not a Coast Survey station, has been included in our longitude system in consequence of its importance a[s] initial longitude station from which many of the United States Lake Survey determinations were made.

(71) A subordinate station; the difference of longitude when referred to the station of 1881 at Saint Louis becomes $19^m\ 35^s.44$

(73) See note to No. 55; mean of the determinations of 1869 and 1871, $35^m\ 31^s.94 \pm 0^s.04$

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
82	Salt Lake City, Temple-block Square, Utah.	Tr't.	A. T. Mosman.	1872	June, July	8	0 26 00.93	±0.04
	Sherman, near railroad station, Wyo.	Mer. T.	R. D. Cutts.					
*83	Brest, station near tower of Saint Louis, France.	△	F. Blake, jr. [J. E. Hilgard].	1872	July.	5	0 17 57.598	±0.028
	Greenwich, Royal Observatory, England.	Tran. C.	G. S. Criswick and others [G. B. Airy].					
*84	Brest, station near tower of Saint Louis, France.	△	F. Blake, jr. [J. E. Hilgard].	1872	Do.	9	0 27 18.512	±0.027
	Paris, Observatory of Paris, France.	Mer. of Fr.	L. F. Folain [Delaunay and Loewy].					
85	Saint Pierre, island of Saint Pierre, Miquelon group, Gulf of Saint Lawrence.	Tr't.	E. Goodfellow [G. W. Dean].	1872	Do.	7	3 26 44.810	±0.027
	Brest, station near tower of Saint Louis, France.	△	F. Blake, jr. [J. E. Hilgard].					
*86	Washington, United States Naval Observatory, D. C.	Dome.	W. Harkness, J. R. Eastman, E. Frisby [B. F. Sands].	1872	July, Aug.	11	0 23 40.967	+0.010
	Cambridge, Harvard College observatory, Mass.	Dome.	E. Smith [J. Winlock].					
87	Washington, United States Naval Observatory, D. C.	Dome.	W. Harkness, J. R. Eastman, E. Frisby [B. F. Sands].	1872	Do.	9	1 23 29.553	+0.027
	Saint Pierre, island of Saint Pierre, Miquelon group, Gulf of Saint Lawrence.	Tr't.	E. Goodfellow [G. W. Dean].					
88	Cambridge, Harvard College observatory, Mass.	Dome.	E. Smith [J. Winlock].	1872	Do.	7	0 59 48.608	±0.021
	Saint Pierre, island of Saint Pierre, Miquelon group, Gulf of Saint Lawrence.	Tr't.	E. Goodfellow [G. W. Dean].					
*89	Greenwich, Royal Observatory, England.	Tran. C.	F. Blake, jr. [G. B. Airy, J. E. Hilgard].	1872	Aug., Sept.	5	0 09 21.000	±0.038
	Paris, Observatory of Paris, France.	Mer. of Fr.	L. F. Folain [Loewy].					
90	Carpenter's Point, near Port Jervis, N. Y.	Tr't.	E. Smith.	1873	May, June	7	0 14 15.67	±0.10
	Cambridge, Harvard College observatory, Mass.	Dome.	W. A. Rogers [J. Winlock].					
91	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.	1873	July	6	0 26 09.849	±0.024
	Madison, grounds of University of Wisconsin, Wis.	Tr't.	F. Blake, jr. [G. W. Dean].					
92	Denver, near railroad depot, Colo.	Mer. T.	E. Smith [G. W. Dean].	1873	July, Aug.	4	0 36 12.20	±0.04
	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.					
93	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	Do.	1873	August	4	0 10 49.567	+0.063
	Minneapolis, grounds of University, Minn.	Tr't.	F. Blake, jr. [G. W. Dean].					
94	Colorado Springs, experimental garden, Colo.	Mer. T.	E. Smith [G. W. Dean].	1873	Do.	4	0 35 30.45	+0.02
	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.					
95	Kalama, Wash. Ter.	Mer. T.	W. Eimbeck.	1873	September	12	0 01 43.88	±0.026
	San Francisco, Washington Square, Cal.	Tr't.	G. Davidson.					
96	Omaha, Capitol Square (grounds of high school), Nebr.	Tr't.	E. Goodfellow.	1873	Do.	4	0 18 46.850	±0.021
	La Crosse, Court-House Square, Wis.	Tr't.	F. Blake, jr. [G. W. Dean].					

(83) The station was $0^s.444$ *east* of the trigonometrical station on the Saint Louis tower, the transit station of 1870 being different from that of 1872, for which reason both were at once referred to the tower station △. The determination of the difference of longitude between the respective transits gave $17^m\ 57^s.154$, which, increased by $0^s.444$, refers it to the tower. The transit circle at the Greenwich observatory marks the Greenwich or initial meridian.

(84) At Brest the position *east* of the tower was referred to the tower, and at Paris the position of the Gambey meridian instrument, which was $0^s.12$ *east* of the meridian of France, was referred to the latter meridian. The Coast Survey result for these points was $\Delta\lambda = 27^m\ 18^s.533 \pm 0^s.038$; in the Annales de l'Observatoire de Paris, Vol. VIII, 1866, p. 279, Le Verrier gives his telegraphic result $= 27^m\ 18^s.49$; the mean value of these two determinations, with equal weight, is given in the table.

(86) The results of 1872 and 1867, viz, $23^m\ 40^s.967$ and $23^m\ 41^s.116$, were combined and the mean result $\Delta\lambda = 23^m\ 41^s.041 \pm 0^s.018$ was finally adopted.

(89) At Greenwich the Coast Survey transit was $0^s.160$ *east* (N. B.—In Coast Survey report for 1874, p. 177, l. 20 from top; for west, read east) of the Greenwich meridian, and at Paris the instrument was $0^s.12$ *east* of the meridian of France, which is the same as that of Cassini. The result in the table is referred to these respective meridians.

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
97	Trinidad, station near jail, Colo.	Mer. T.	E. Smith [G. W. Dean].	1873	September	3	0 34 14.20	±0.03
	Omaha, Capitol Square (grounds of high school) Nebr.	Tr't.	E. Goodfellow.					
φ	Ogden, United States Engineers' observatory, Utah.	East Tr't	F. Kampf.	1873	Sept., Oct.	6	0 00 24.747	±0.060
	Salt Lake City, Temple-block station, Utah.	Tr't.	J. H. Clark.					
φ	Ogden, United States Engineers' observatory, Utah.	East Tr't	F. Kampf.	1873	Do.	5	1 55 47.471	±0.068
	Detroit, United States Lake Survey observatory, Mich.	East Tr't	O. B. Wheeler.					
98	Key West, Clinton Place, Fla.	Mer. T.	E. Smith.	1873	December	7	0 19 01.554	±0.017
	Washington, United States Naval Observatory, D. C.	Dome.	W. Harkness, J. R. Eastman, E. Frisby [B. F. Sands].	1874	January			
99	Punta Rasa, Charlotte Harbor, Fla.	Mer. T.	E. Smith.	1874	February	4	0 03 41.45	±0.04
	Savannah, Exchange station, Ga.	Tr't.	F. Blake, jr.					
100	Savannah, Exchange station, Ga.	Tr't.	Do.	1874	Feb., Mar.	7	0 16 09.30	±0.07
	Washington, United States Naval Observatory, D. C.	Dome.	W. Harkness, J. R. Eastman [C. H. Davis].					
101	Cedar Keys, near railroad depot, Fla.	Mer. T.	E. Smith.	1874	March	5	0 07 45.95	±0.04
	Savannah, Exchange station, Ga.	Tr't.	F. Blake, jr.					
102	Atlanta, City-Hall Square, Ga.	Mer. T.	E. Smith.	1874	Do.	6	0 13 11.96	±0.046
	Savannah, Exchange station, Ga.	Tr't.	F. Blake, jr.					
φ	Ogden, United States Engineers' observatory, Utah.	East Tr't	J. H. Clark.	1874	October	5	2 19 47.515	±0.067
	Washington, United States Naval Observatory, D. C.	Dome.	J. R. Eastman.					
103	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.	1877	July, Aug.	10	0 15 09.125	±0.025
	Columbus, Capitol grounds, Ohio.	Tr't.	W. Eimbeck.					
	Washington, United States Naval Observatory, D. C.	Dome.	J. R. Eastman, E. Frisby, A. N. Skinner, H. M. Paul [J. Rodgers].					
104	Travis, near Hale's Eddy, N. Y.	Mer. T.	E. Smith.	1877	July	3	0 06 46.54	±0.06
105	Burt, near Wellsburg, Pa.	Mer. T.	Do.	1877	August	2	0 01 17.43	±0.05
106	Finn, near Great Bend Village, N. Y.	Mer. T.	Do.	1877	Aug., Sept.	4	0 05 09.95	±0.03
107	Columbus, Capitol grounds, Ohio.	Mer. T.	W. Eimbeck.	1877	August	6	0 23 46.816	±0.038
	Washington, United States Naval Observatory, D. C.	Dome.	J. R. Eastman, E. Frisby, A. N. Skinner [J. Rodgers].					
108	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean, H. W. Blair.	1877	Aug., Oct.	13	0 38 55.988	±0.040
	Washington, United States Naval Observatory, D. C.	Dome.	J. R. Eastman, E. Frisby, A. N. Skinner [J. Rodgers].					
109	Washington, United States Naval Observatory, D. C.	Dome.	E. Frisby [J. Rodgers].	1877	Sept.	5	0 00 40.79	±0.03
	Harrisburg, grounds State Capitol, Pa.	Mer. T.	E. Smith.					
110	Paducah, Court-House Square, Ky.	Tr't.	W. Eimbeck.	1877	Do.	3	0 07 15.77	±0.03
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
111	Cairo, Custom-House block, Ill.	Tr't.	W. Eimbeck.	1877	October	3	0 09 33.05	±0.03
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
112	Hickman, Court-House lot, Ky.	Tr't.	W. Eimbeck.	1877	Do.	3	0 09 38.72	±0.03
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
113	Memphis, Custom-House Square, Tenn.	Tr't.	W. Eimbeck.	1877	November	5	0 13 05.06	±0.03
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
114	Summit, station of Central Pacific Railroad, Cal.	Mer. T.	B. A. Colonna.	1878	May	4	2 53 07.57	±0.16
	Washington, United States Naval Observatory, D. C.	Dome.	Various observers [C. H. Davis].					
115	Helena, Court-House grounds, Ark.	Mer. T.	E. Smith.	1878	Do.	3	0 15 13.59	±0.02
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
116	San Francisco, Washington Square, Cal.	Tr't.	J. F. Pratt.	1878	May, June	6	0 08 19.01	±0.06
	Summit, station Central Pacific Railroad, Cal.	Mer. T.	B. A. Colonna.					

(φ) The three determinations of Ogden observatory, the fundamental western longitude station of the United States Engineers, though no included in the operations of the Coast Survey, yet indirectly connected with it, are here given on account of the importance of the position of this observatory. It holds the same place with respect to the United States Engineers' surveys as Detroit did with the United States Lake Survey. The probable errors have been increased to allow for probable error of personal equation. It was connected with Salt Lake City and Detroit in 1873, and with Washington in 1874.

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
117	Natchez, grounds near Catholic church, Miss.	Mer. T.	E. Smith.	1878	June	3	0 18 28.24	±0.05
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
118	Vicksburg, station in fort, Miss.	Mer. T.	E. Smith.	1878	July	3	0 16 24.15	±0.05
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
119	Greenville, near Episcopal church, Miss.	Mer. T.	E. Smith.	1878	Do.	3	0 17 07.43	±0.03
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean.					
120	Statesville, Simonton College station, N. C.	Tr't.	E. Smith, G. W. Dean.	1878	December	4+3	0 15 22.601	±0.016
	Washington, grounds Naval Observatory, D. C.	Dome.	G. W. Dean, E. Smith.	1879	January			
121	Atlanta, City-Hall Square, Ga.	Tr't.	Do.	1879	Jan., Feb., March	5+6	0 29 21.184	±0.019
	Washington, grounds Naval Observatory, D. C.	Dome.	E. Smith, G. W. Dean.					
122	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean, E. Smith.	1879	Nov., Dec.	3+3	0 04 04.459	±0.017
	Louisville, grounds of University, Ky.	Tr't.	E. Smith, G. W. Dean.					
123	Nashville, State-House Square, Tenn.	Tr't.	Do.	1879	December	5+5	0 09 34.748	±0.017
	Atlanta, City-Hall Square, Ga.	Tr't.	G. W. Dean, E. Smith.	1880	January			
*124	New Orleans, Lafayette Square, La.	Tr't.	E. Smith, G. W. Dean.	1880	Feb., Mar.	5+5	0 13 08.669	±0.017
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean, E. Smith.					
125	New Orleans, Lafayette Square, La.	Tr't.	Do.	1880	Mar., April	4+5	0 22 43.382	±0.016
	Atlanta, City-Hall Square, Ga.	Tr't.	E. Smith, G. W. Dean.					
126	Baton Rouge, grounds United States barracks, La.	Mer. T.	E. Smith.	1880	April	4	0 27 11.91	±0.03
	Atlanta, City-Hall Square, Ga.	Tr't.	G. W. Dean.					
*127	Atlanta, City-Hall Square, Ga.	Tr't.	E. Smith, G. W. Dean.	1880	May	5+5	0 17 49.224	±0.012
	Charleston, Citadel Square, S. C.	Tr't.	G. W. Dean, E. Smith.					
128	Washington, grounds Naval Observatory, D. C.	Dome.	E. Smith, G. W. Dean.	1881	Do.	5+5	0 08 29.072	±0.011
	Cape May, Pennsylvania Railroad Company's grounds, N. J.	Tr't.	G. W. Dean, E. Smith.					
††	Detroit, United States Lake Survey observatory, Mich.	E. Tr't.	A. R. Flint, O. B. Wheeler [C. B. Comstock].	1881	May, June	6+5	0 47 41.172	±0.031
	Cambridge, Harvard College observatory, Mass.	Dome.	O. B. Wheeler, A. R. Flint.					
129	Strasburg, earthworks north of town, Va.	Tr't.	E. Smith, G. W. Dean.	1881	June	3+3	0 05 14.230	±0.010
	Washington, grounds of Naval Observatory, D. C.	Dome.	G. W. Dean, E. Smith.					
130	Cincinnati, grounds of Mount Lookout observatory, Ohio.	Dome.	Do.	1881	July, Aug.	4+5	0 29 29.262	±0.013
	Washington, grounds United States Naval Observatory, D C.	Dome.	E. Smith, G. W. Dean.					
131	Nashville, State-House Square, Tenn,	Tr't.	C. H. Sinclair, E. Smith.	1881	Aug., Sept.	4+4	0 09 26.682	±0.009
	Cincinnati, grounds Mount Lookout observatory, Ohio.	Dome.	E. Smith, C. H. Sinclair.					
*132	Saint Louis, observatory of Washington University, Mo.	Tr't.	E. Smith, G. W. Dean.	1881	Sept., Oct.	4+4	0 23 07.893	±0.017
	Cincinnati, grounds Mount Lookout observatory, Ohio.	Dome.	G. W. Dean, E. Smith.					
133	Saint Louis, observatory of Washington University, Mo.	Tr't.	Do.	1881	Oct., Nov.	3+4	0 13 41.207	±0.014
	Nashville, State-House Square, Tenn.	Tr't.	E. Smith, G. W. Dean.					
134	Vincennes, Court-House yard, Ind.	Tr't.	Do.	1881	November	3+3	0 02 57.886	±0.025
	Nashville, State-House Square, Tenn.	Tr't.	G. W. Dean, E. Smith.					
135	Saint Louis, observatory of Washington University, Mo.	Tr't.	E. Smith, C. H. Sinclair.	1881	Nov., Dec.	4+3	0 10 43.230	±0.006
	Vincennes, Court-House yard, Ind.	Tr't.	C. H. Sinclair, E. Smith.					
*136	Charlottesville, McCormick observatory, University of Virginia, Va.	Dome.	C. H. Sinclair, F. H. Parsons.	1882	July, Aug.	3+4	0 05 48.681	±0.017
	Washington, grounds United States Naval Observatory, D. C.	Dome.	F. H. Parsons, C. H. Sinclair.					

(124) The old station near intersection of Basin and Canal streets of 1858 could no longer be used and a new station was established in Lafayette Square and geodetically connected with the former; see note to No. 27.

(††) Not a Coast and Geodetic Survey station, but included for reason stated in note to † page 412.

(130) The old observatory, established by O. M. Mitchel on Mount Adams, electrically connected by the Coast Survey in 1848 with Philadelphia, has at present no connection, geodetic or astronomical, with the new observatory on Mount Lookout.

(132) The old station of 1869–'71 could not be recovered in 1881, when a new location, the small observatory in the grounds of the Washington University was selected. It is *west* of the old station $0^s.125$; see note to No. 71.

(136) The reference at Charlottesville is to the *dome* of the *University*.

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
137	Kansas City, grounds Franklin school, Mo.	Tr't.	C. H. Sinclair, C. Terry, jr. [G. W. Dean].	1882	Sept., Oct.	5+5	0 17 32.199	±0.021
	Saint Louis, observatory of Washington University, Mo.	Tr't.	C. Terry, jr., C. H. Sinclair.					
138	Saint Louis, observatory of Washington University, Mo.	Tr't.	C. Terry, jr., C. H. Sinclair [G. W. Dean].	1882	Do.	3	0 24 27.82	±0.09
	London, near railroad depot, Ky.	Tr't.	F H. Parsons.					
139	Saint Louis, observatory of Washington University, Mo.	Tr't.	C. H. Sinclair [G. W. Dean].	1882	October	3	0 12 10.73	±0.18
	Guthrie, near post-office, Ky.	Tr't.	F. H. Parsons.					
140	Saint Louis, observatory of Washington University, Mo.	Tr't.	C. H. Sinclair [G. W. Dean].	1882	Do.	3	0 10 27.39	±0.03
	Henderson, near Court-House, Ky.	Tr't.	F. H. Parsons.					
141	Omaha, grounds of high school, Nebr.	Tr't.	C. Terry, jr., C. H. Sinclair [G. W. Dean].	1882	Oct., Nov.	5+5	0 22 56.825	± 0.012
	Saint Louis, observatory of Washington University, Mo.	Tr't.	C. H. Sinclair, C. Terry, jr.					
142	Little Rock, yard of government building, Ark.	Tr't.	F. H. Parsons.	1882	November	3	0 08 16.42	±0.02
	Saint Louis, observatory of Washington University, Mo.	Tr't.	C. Terry, jr. [G. W. Dean].					
*143	Saint Louis, observatory of Washington University, Mo.	Tr't.	Do.	1882	Do.	2	0 02 11.87	±0.04
	Springfield, State-House grounds, Ill.	Tr't.	F. H. Parsons.					
*144	Omaha, grounds of high school, Nebr.	Tr't.	C. H. Sinclair [G. W. Dean].	1882	Do.	1	0 25 08.76	±0.15
	Springfield, State-House grounds, Ill.	Tr't.	F. H. Parsons.					
*145	Saint Augustine, Fort Marion, Fla.	Mer. C.	Captain Defforges, E. D. Preston [Col. F. Perrier].	1882	Nov., Dec.	- -	- - - -	- -
	Savannah, Exchange station, Ga.	Tr't.	E. D. Preston, Capt. Defforges.					
146	Kansas City, grounds of Franklin school, Mo.	Tr't.	C. Terry, jr. [G. W. Dean].	1882	Do.	3	0 33 42.86	±0.06
	Indianapolis, grounds of State-House, Ind.	Tr't.	F. H. Parsons.					
*147	San Francisco, Lafayette Park, Cal.	Tr't.	J. J. Gilbert.	1882	December	- -	- - - -	- -
	Fort Selden, parade grounds, N. Mex.	Mer. T.	G. Davidson.					
148	Omaha, grounds high school, Nebr.	Tr't.	C. H. Sinclair, C. Terry, jr. [G. W. Dean].	1882 1883	Nov., Dec., Jan.	5+5	0 05 24.621	±0.021
	Kansas City, grounds of Franklin school, Mo.	Tr't.	C. Terry, jr., C. H. Sinclair.					
149	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, jr. [G. W. Dean].	1883	May	3	0 05 02.08	±0.05
	Lexington, grounds of College of Agriculture and Mechanics, Ky.	Tr't.	F. H. Parsons.					
150	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, jr. [G. W. Dean].	1883	June	3	0 12 39.10	±0.03
	Louisa, near Cross and Franklin streets, Ky.	Tr't.	F. H. Parsons.					
151	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, jr. [G. W. Dean].	1883	Do.	3	0 01 03.75	±0.03
	Greensburg, near C. & O. Railroad engine-house, Ky.	Tr't.	F. H. Parsons.					
152	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, jr. [G. W. Dean].	1883	July	3	0 06 33.59	±0.03
	Jellico, near depot of L. & N. Railroad, Tenn.	Tr't.	F. H. Parsons.					
153	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, jr. [G. W. Dean].	1883	Do.	3	0 05 52.10	±0.03
	Richmond, grounds Kentucky Central College, Ky.	Tr't.	F. H. Parsons.					
154	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, jr. [G. W. Dean].	1883	Do.	2	0 21 03.39	±0.07
	Smith's Ferry, near boundary on Ohio, Pa.	Tr't.	C. H. Sinclair.					
155	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, jr., F. H. Parsons [G. W. Dean].	1883	Aug., Sept.	5+5	0 16 31.508	±0.016
	Charleston, grounds of State House, W. Va.	Tr't.	F. H. Parsons, C. Terry, jr.					

(143) The direct result is $2^m\ 11^s.87$; the adjusted, $2^m\ 11^s.89$, taking in Omaha and Springfield.

(144) The direct result is $25^m\ 08^s.76$; the adjusted, $25^m\ 08^s.71$, with consideration of the determinations Omaha-Springfield, 1869 and 1882, and Omaha-Saint Louis, 1882.

(145) Determined in connection with the observations of the Transit of Venus by the French party in charge of Colonel Perrier. The French records have not yet been communicated.

(147) Determined in connection with the observations of the Transit of Venus by the Coast and Geodetic Survey party in charge of Assistant G. Davidson. Result not yet known. The Davidson Astronomical Observatory, in Lafayette Park, is about a statute mile westward of the observatory in Washington Square, San Francisco.

TABLE I.—*General table of results for differences of longitude, &c.*—Continued.

No.	Western and Eastern stations.	Reference mark.	Observer. [Chief of party or of place.]	Year.	Month.	No. of days of determinations.	Difference of longitude.	Probable error.
							h. m. s.	s.
156	Logansport, grounds of Central high school, Ind.	Tr't.	F. H. Parsons.	1883	September.	3	0 02 20.85	±0.04
	Louisville, grounds of high school, Ky.	Tr't.	C. Terry [G. W. Dean].					
*157	Chicago, University grounds, Ill.	Tr't.	F. H. Parsons, C. Terry.	1883	Sept., Oct., Nov.	7+5	0 07 23.544	±0.017
	Louisville, grounds of high school, Ky.	Tr't.	C. Terry, F. H. Parsons [G. W. Dean].					
158	Covington, near C. & O. Railroad depot, Va.	Mer. T.	C. H. Sinclair.	1883 1884	Dec., Jan.	3	0 11 46.52	±0.07
	Washington, grounds of United States Naval Observatory, D. C.	Dome.	F. H. Parsons.					

(157) The Coast and Geodetic Survey transit instrument was mounted in the meridian of the Dearborn observatory meridian circle.

The following Table II contains the observed values for the differences of longitude of all stations forming part of a connected system, and which is joined directly with that of Europe. Thus it contains only those 53 measures between which rigid geometrical conditions subsist, which it was the object of the present adjustment to satisfy; this was done by application of the method of least squares, and Table II is arranged suitably for that purpose.

Column one gives the year of observation, column two the names of the western and eastern stations, and column three their observed difference of longitude directly taken from Table I. The fourth column contains the probable error of the measure *a priori* assigned; the fifth column gives the corresponding value of the reciprocal of the weight, and the last column contains the symbolical correction to the observed value. Let l_i be an observed difference of longitude where i represents integers from 1 to 53 inclusive; e_i its probable error, and $\frac{1}{p_i} = 10^5 e_i^2$ the weight as used in the computation, the multiplier 10^5 being introduced for convenience; also let δ_i be the correction and x_i the most probable value of the observed quantity, then $l_i + \delta_i = x_i$

TABLE II.—*Observed differences of longitude, their probable errors, numbers for reciprocal of weights and symbolic corrections.*

Year.	Western station.	Eastern station.	Observed differences of longitude.	Probable error.	$\frac{1}{p_i} = e^2$	δ_i
			h. m. s.	s.		
1872	Greenwich, England.	Paris, France.	0 09 21.000	±0.038	.00144	(1)
1872	Brest, France.	Greenwich, England.	0 17 57.598	.022	48	(2)
1863 1872	Brest, France.	Paris, France.	0 27 18.512	.027	73	(3)
1851	Cambridge, Mass.	Bangor, Me.	0 09 23.080	.043	185	(4)
1857	Bangor, Me.	Calais, Me.	0 06 00.316	.015	22	(5)
1866	Calais, Me.	Heart's Content, Newfoundland.	0 55 37.973	.066	436	(6)
1866	Heart's Content, Newfoundland.	Foilhommerum, Ireland.	2 51 56.356	.029	84	(7)
1866	Foilhommerum, Ireland.	Greenwich, England.	0 41 33.336	.049	240	(8)
1872	Saint Pierre, Gulf of Saint Lawrence.	Brest, France.	3 26 44.810	.027	73	(9)
1872	Cambridge, Mass.	Saint Pierre, Gulf of Saint Lawrence.	0 59 48.608	.021	44	(10)
1870	Duxbury, Mass.	Brest, France.	4 24 43.276	.047	221	(11)
1869 1870	Cambridge, Mass.	Duxbury, Mass.	0 01 50.191	.022	48	(12)

TABLE II.—*Observed differences of longitude, their probable errors, &c.*—Continued.

Year.	Western station.	Eastern station.	Observed differences of longitude.			Probable error.	$\frac{1}{p_1}=\epsilon^2$	δ_1
			h.	m.	s.	s.		
1867, 1872	Washington, D. C.	Cambridge, Mass.	0	23	41.041	±0.018	.00032	(13)
1872	Washington, D. C.	Saint Pierre, Gulf of Saint Lawrence.	1	23	29.553	.027	73	(14)
1867	Seaton, D. C.	Cambridge, Mass.	0	23	28.474	.023	53	(15)
1867	Washington, D. C.	Seaton, D. C.	0	00	12.634	.015	22	(16)
1852	Petersburg, Va.	Seaton, D. C.	0	01	35.591	.022	48	(17)
1853	Raleigh, N. C.	Seaton, D. C.	0	06	32.873	.044	194	(18)
1853	Charleston (1880), S. C.	Raleigh, N. C.	0	05	11.68	.15	2250	(19)
1854	Columbia, S. C.	Raleigh, N. C.	0	09	35.862	.041	168	(20)
1854	Wilmington, N. C.	Petersburg, Va.	0	02	11.340	.033	109	(21)
1856	Columbia, S. C.	Wilmington, N. C.	0	12	21.731	.028	78	(22)
1874	Atlanta, Ga.	Savannah, Ga.	0	13	11.96	.046	212	(23)
1879	Atlanta, Ga.	Washington, D. C.	0	29	21.184	.019	36	(24)
1874	Savannah, Ga.	Washington, D. C.	0	16	09.30	.67	490	(25)
1855	Macon, Ga.	Columbia, S. C.	0	10	22.250	.051	260	(26)
1856	Montgomery, Ala.	Macon, Ga.	0	10	41.570	.015	22	(27)
1857	Lower Peach Tree, Ala.	Montgomery, Ala.	0	04	58.789	.016	26	(28)
1857	Mobile, Ala.	Lower Peach Tree, Ala.	0	01	59.768	.016	26	(29)
1858	New Orleans (1880), La.	Mobile, Ala.	0	08	06.281	.022	48	(30)
1880	New Orleans, La.	Nashville, Tenn.	0	13	08.669	.017	29	(31)
1880	New Orleans, La.	Atlanta, Ga.	0	22	43.382	.016	26	(32)
1877	Nashville, Tenn.	Washington, D. C.	0	38	55.988	.040	160	(33)
1879, 1880	Nashville, Tenn.	Atlanta, Ga.	0	09	34.748	.017	29	(34)
1880	Atlanta, Ga.	Charleston, S. C.	0	17	49.224	.012	14	(35)
1877	Nashville, Tenn.	Columbus, Ohio.	0	15	09.125	.025	62	(36)
1877	Columbus, Ohio.	Washington, D. C.	0	23	46.816	.038	144	(37)
1871	Columbus, Ohio.	Cleveland, Ohio.	0	05	12.929	.045	202	(38)
1871	Cleveland, Ohio.	Cambridge, Mass.	0	42	14.875	.038	144	(39)
1871	Columbus, Ohio.	Cambridge, Mass.	0	47	27.713	.035	122	(40)
1881	Detroit, Mich.	Cambridge, Mass.	0	47	41.172	.031	96	(41)
1871	Detroit, Mich.	Washington, D. C.	0	24	00.15	.06	360	(42)
1881	Cincinnati, Ohio.	Washington, D. C.	0	29	29.262	.013	17	(43)
1881	Nashville, Tenn.	Cincinnati, Ohio.	0	09	26.682	.009	8	(44)
1881	Saint Louis, Mo.	Nashville, Tenn.	0	13	41.207	.014	20	(45)
1870	Saint Louis (1881), Mo.	Washington, D. C.	0	52	37.026	.026	68	(46)
1881	Saint Louis, Mo.	Cincinnati, Ohio.	0	23	07.893	.017	29	(47)
1881	Saint Louis, Mo.	Vincennes, Ind.	0	10	43.230	.006	4	(48)
1881	Vincennes, Ind.	Nashville, Tenn.	0	02	57.886	.025	62	(49)
1869	Omaha, Nebr.	Cambridge, Mass.	1	39	15.065	.023	53	(50)
1882	Omaha, Nebr.	Saint Louis, Mo.	0	22	56.825	.012	14	(51)
1882	Kansas City, Mo.	Saint Louis, Mo.	0	17	32.199	.021	44	(52)
1882, 1883	Omaha, Nebr.	Kansas City, Mo.	0	05	24.621	.021	44	(53)

The average e^2 equals .00142, hence the average probable error of the tabular quantities$=\pm 0^s.038$ It may be stated that since 1878, when certain improvements were introduced, the average probable error of a determination $\triangle \lambda$, as deduced from 14 values (varying between the limits $\pm 0^s.006$ and $0^s.025$), equaled $\pm 0^s.016$, which amount may be regarded as a measure of the degree of accuracy attained by the Survey of late years.

There are admitted in the present scheme 53 longitude determinations between 33 stations; hence the number of conditions to be satisfied, $53-33+1=21$.

The conditional equations will be of the form

$$\begin{array}{l} a_1\,\delta_1+a_2\,\delta_2+a_3\,\delta_3+\;\;\ldots\ldots\;\;+w_1=0 \\ b_1\,\delta_1+b_2\,\delta_2+b_3\,\delta_3+\;\;\ldots\ldots\;\;+w_2=0 \\ c_1\,\delta_1+c_2\,\delta_2+c_3\,\delta_3+\;\;\ldots\ldots\;\;+w_3=0 \\ \text{etc.} \end{array}$$

and introducing the correlates C_i where i represents integers from 1 to 21 inclusive, we have the usual normal* and correlate equations:

$$\begin{array}{llll} [u.\,aa]\,C_1+[u.\,ab]\,C_2+[u.\,ac]\,C_3+ & \ldots\ldots & +w_1=0 \\ \text{etc.}\quad +[u.\,bb]\,C_2+[u.\,bc]\,C_3+ & \ldots\ldots & +w_2=0 \\ \text{etc.}\qquad\qquad +[u.\,cc]\,C_3+ & \ldots\ldots & +w_3=0 \end{array}$$

$$\begin{array}{l} p_1\,\delta_1=a_1\,C_1+b_1\,C_2+c_1\,C_3+\;\;\ldots\ldots \\ p_2\,\delta_2=a_2\,C_1+b_2\,C_2+c_2\,C_3+\;\;\ldots\ldots \\ p_3\,\delta_3=a_3\,C_1+b_3\,C_2+c_3\,C_3+\;\;\ldots\ldots \\ \text{etc.} \end{array}$$

The reduced conditional equations to be satisfied are as follows:

$$\begin{array}{l}
0 = +\,0^s.086 + (1) + (2) - (3) \\
0 = +\,0\,.045 - (2) + (4) + (5) + (6) + (7) + (8) - (9) - (10) \\
0 = -\,0\,.049 + (9) + (10) - (11) - (12) \\
0 = +\,0\,.096 + (10) + (13) - (14) \\
0 = -\,0\,.067 + (13) - (15) - (16) \\
0 = +\,0\,.193 - (16) + (18) + (20) - (24) + (26) + (27) + (28) + (29) + (30) - (32) \\
0 = -\,0\,.076 - (23) + (24) - (25) \\
0 = -\,0\,.073 + (17) - (18) - (20) + (21) + (22) \\
0 = +\,0\,.041 + (16) - (18) - (19) + (24) - (35) \\
0 = -\,0\,.056 + (24) - (33) + (34) \\
0 = +\,0\,.035 + (31) - (32) + (34) \\
0 = +\,0\,.047 + (33) - (36) - (37) \\
0 = -\,0\,.144 - (13) - (37) + (40) \\
0 = +\,0\,.091 + (38) + (39) - (40) \\
0 = +\,0\,.019 + (13) - (41) + (42) \\
0 = -\,0\,.044 - (33) + (43) + (44) \\
0 = +\,0\,.169 + (33) + (45) - (46) \\
0 = -\,0\,.004 + (44) + (45) - (47) \\
0 = +\,0\,.091 + (45) - (48) - (49) \\
0 = -\,0\,.173 + (13) + (46) - (50) + (51) \\
0 = +\,0\,.005 + (51) - (52) - (53)
\end{array}$$

* To avoid fractional notation we write u for $\frac{1}{p}$

Scheme of coefficients and of inverse weights for the formation of normal equations and for computing the corrections expressed in terms of the correlates.

	Correction δ_i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
	$u=\frac{1}{p}$	144	48	73	185	22	436	84	240	73	44	221	48	32	73	53	22	48	194	2250	168	109	78	212	36	490	260	22
Correlates.	C_1 *a*	+1	+1	−1																								
	C_2 *b*		−1		+1	+1	+1	+1	+1	−1	−1																	
	C_3 *c*									+1	+1	−1	−1															
	C_4 *d*										+1			+1	−1													
	C_5 *e*													+1		−1	−1											
	C_6 *f*																−1		+1		+1				−1		+1	+1
	C_7 *g*																							−1	+1	−1		
	C_8 *h*																	+1	−1		−1	+1	+1					
	C_9 *i*																+1		−1	−1					+1			
	C_{10} *j*																								+1			
	C_{11} *k*																											
	C_{12} *l*																											
	C_{13} *m*													−1														
	C_{14} *n*																											
	C_{15} *o*													+1														
	C_{16} *p*																											
	C_{17} *q*																											
	C_{18} *r*																											
	C_{19} *s*																											
	C_{20} *t*													+1														
	C_{21} *u*																											
	(Wash.) *f*		+1							+1					+1													
	(Camb.) *f*		+1							+1	+1																	

	Correction δ_i	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	Discrepancies
	$u=\frac{1}{p}$	26	26	48	29	26	160	29	14	62	144	202	144	122	96	360	17	8	20	68	29	4	62	53	14	44	44	*w*
Correlates.	C_1 *a*																											+0.086
	C_2 *b*																											+ .045
	C_3 *c*																											− .049
	C_4 *d*																											+ .096
	C_5 *e*																											− .067
	C_6 *f*	+1	+1	+1		−1																						+ .193
	C_7 *g*																											− .076
	C_8 *h*																											− .073
	C_9 *i*								−1																			+ .041
	C_{10} *j*						−1	+1																				− .056
	C_{11} *k*				+1	−1		+1																				+ .035
	C_{12} *l*						+1			−1	−1																	+ .047
	C_{13} *m*										−1			+1														− .144
	C_{14} *n*											+1	+1	−1														+ .091
	C_{15} *o*														−1	+1												+ .019
	C_{16} *p*						−1										+1	+1										− .044
	C_{17} *q*						+1												+1	−1								+ .169
	C_{18} *r*																	+1	+1		−1							− .004
	C_{19} *s*																		+1			−1	−1					+ .091
	C_{20} *t*																			+1				−1	+1			− .173
	C_{21} *u*																								+1	−1	−1	+ .005
	(Wash.) *f*																											
	(Camb.) *f*																											

Normal equations.

C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	w
+265	− 48																				+.086=0
− 48	+1132	−117	− 44																		+.045=0
	− 117	+386	+ 44																		−.049=0
	− 44	+ 44	+149	+ 32								− 32		+ 32					+ 32		+.096=0
			+ 32	+107	+ 22			− 22				− 32		+ 32					+ 32		−.067=0
				+ 22	+828	− 36	−362	− 252	− 36	+26											+.193=0
					− 36	+738		+ 36	+ 36												−.076=0
					−362		+597	+ 194													−.073=0
				− 22	−252	+ 36	+194	+2516	+ 36												+.041=0
					− 36	+ 36		+ 36	+225	+29	−160				+160	−160					−.056=0
					+ 26				+ 29	+84											+.035=0
									−160		+366	+144			−160	+160					+.047=0
			− 32	− 32							+144	+298	−122	− 32					− 32		−.144=0
												−122	+468								+.091=0
			+ 32	+ 32								− 32		+488					+ 32		+.019=0
									+160		−160				+185	−160	+ 8				−.044=0
									−160		+160				−160	+248	+20	+20	− 68		+.169=0
															+ 8	+ 20	+57	+20			−.004=0
																+ 20	+20	+86			+.091=0
			+ 32	+ 32								− 32		+ 32		− 68			+167	+ 14	−.173=0
																			+ 14	+102	+.005=0

Solving the respective equations we obtain the following values of C_i and of δ_i whence the corrected measures x_i as below:

	C_i		C_i
1	−.0003370	12	−.0005894
2	− 690	13	+ 8924
3	+ 2152	14	+ 380
4	− 9584	15	− 495
5	+ 9138	16	− 6141
6	− 2647	17	− 3583
7	+ 915	18	+ 6800
8	− 270	19	− 11330
9	− 341	20	+ 10960
10	+ 41	21	−.0001995
11	− 3363		

	Names of stations.	Measured $\Delta\lambda$	Correction δ_i	Seconds corrected.
		h. *m.* *s.*	*s.*	*s.*
1	Greenwich–Paris	0 09 21.000	−0.048	20.952
2	Brest–Greenwich	0 17 57.598	− .013	57.585
3	Brest–Paris	0 27 18.512	+ .025	18.537
4	Cambridge–Bangor	0 09 23.080	− .013	23.067
5	Bangor–Calais	0 06 00.316	− .002	00.314
6	Calais–Heart's Content	0 55 37.973	− .030	37.943
7	Heart's Content–Foilhommerum	2 51 56.356	− .006	56.350
8	Foilhommerum–Greenwich	0 41 33.336	− .017	33.319

Values of C_1 and of δ_1—Continued.

	Names of stations.	Measured Δλ			Correction δ_1	Seconds corrected.
		h.	*m.*	*s.*	*s.*	*s.*
9	Saint Pierre–Brest	3	26	44.810	+ .021	44.831
10	Cambridge–Saint Pierre	0	59	48.608	— .030	48.578
11	Duxbury–Brest	4	24	43.276	— .048	43.228
12	Cambridge–Duxbury	0	01	50.191	— .010	50.181
13	Washington–Cambridge	0	23	41.041	+ .004	41.045
14	Washington–Saint Pierre	1	23	29.553	+ .070	29.623
15	Seaton–Cambridge	0	23	28.474	— .048	28.426
16	Washington–Seaton	0	00	12.634	— .015	12.619
17	Petersburg–Seaton	0	01	35.591	— .001	35.590
18	Raleigh–Seaton	0	06	32.873	— .040	32.833
19	Charleston–Raleigh	0	05	11.680	+ .077	11.757
20	Columbia–Raleigh	0	09	35.862	— .040	35.822
21	Wilmington–Petersburg	0	02	11.340	— .003	11.337
22	Columbia–Wilmington	0	12	21.731	— .002	21.729
23	Atlanta–Savannah	0	13	11.960	— .019	11.941
24	Atlanta–Washington	0	29	21.184	+ .012	21.196
25	Savannah–Washington	0	16	09.300	— .045	09.255
26	Macon–Columbia	0	10	22.250	— .069	22.181
27	Montgomery–Macon	0	10	41.570	— .006	41.564
28	Lower Peach Tree–Montgomery	0	04	58.789	— .007	58.782
29	Mobile–Lower Peach Tree	0	01	59.768	— .007	59.761
30	New Orleans–Mobile	0	08	06.281	— .013	06.268
31	New Orleans–Nashville	0	13	08.669	— .010	08.659
32	New Orleans–Atlanta	0	22	43.382	+ .016	43.398
33	Nashville–Washington	0	38	55.988	— .054	55.934
34	Nashville–Atlanta	0	09	34.748	— .010	34.738
35	Atlanta–Charleston	0	17	49.224	+ .000	49.224
36	Nashville–Columbus	0	15	09.125	+ .036	09.161
37	Columbus–Washington	0	23	46.816	— .044	46.772
38	Columbus–Cleveland	0	05	12.929	+ .008	12.937
39	Cleveland–Cambridge	0	42	14.875	+ .006	14.881
40	Columbus–Cambridge	0	47	27.713	+ .104	27.817
41	Detroit–Cambridge	0	47	41.172	+ .005	41.177
42	Detroit–Washington	0	24	00.150	— .018	00.132
43	Cincinnati–Washington	0	29	29.262	— .010	29.252
44	Nashville–Cincinnati	0	09	26.682	+ .000	26.682
45	Saint Louis–Nashville	0	13	41.207	— .016	41.191
46	Saint Louis–Washington	0	52	37.026	+ .099	37.125
47	Saint Louis–Cincinnati	0	23	07.893	— .020	07.873
48	Saint Louis–Vincennes	0	10	43.230	+ .004	43.234
49	Vincennes–Nashville	0	02	57.886	+ .070	57.956
50	Omaha–Cambridge	1	39	15.065	— .058	15.007
51	Omaha–Saint Louis	0	22	56.825	+ .013	56.838
52	Kansas City–Saint Louis	0	17	32.199	+ .009	32.208
53	Omaha–Kansas City	0	05	24.621	+ .009	24.630

If we put these results together, we have the final longitudes λ as follows (east longitudes being marked +, west longitudes from Greenwich −, in accordance with a decision of the International Meridian Conference held at Washington last October):

	Longitude stations.	λ		
		h.	m.	s.
1	Greenwich, Transit Circle, Observatory; England.	0	00	00.000
2	Paris, Meridian of France, Observatory; France.	+0	09	20.952
3	Brest, Tower of Saint Louis; France.	−0	17	57.585
4	Foilhommerum, Transit; Ireland.	−0	41	33.319
5	Heart's Content, Transit; Newfoundland.	−3	33	29.669
6	Calais, Transit; Maine.	−4	29	07.612
7	Bangor, Transit; Maine.	−4	35	07.926
8	Cambridge, Dome of Observatory, Harvard College; Massachusetts.	−4	44	30.993
9	Saint Pierre, Transit; Gulf of Saint Lawrence.	−3	44	42.415
10	Duxbury, Transit; Massachusetts.	−4	42	40.812
11	Washington, Dome of United States Naval Observatory; District of Columbia.	−5	08	12.038
12	Seaton, Transit, Washington, D. C.; District of Columbia.	−5	07	59.419
13	Petersburg, Transit; Virginia.	−5	09	35.009
14	Raleigh, Transit; North Carolina.	−5	14	32.252
15	Wilmington, Transit; North Carolina.	−5	11	46.346
16	Columbia, Transit; South Carolina.	−5	24	08.074
17	Atlanta, Transit; Georgia.	−5	37	33.234
18	Charleston, Transit (1880); South Carolina,	−5	19	44.009
19	Savannah, Transit; Georgia.	−5	24	21.293
20	Macon, Transit; Georgia.	−5	34	30.255
21	Montgomery, Transit; Alabama.	−5	45	11.819
22	Lower Peach Tree, Transit; Alabama.	−5	50	10.601
23	Mobile, Transit; Alabama.	−5	52	10.362
24	Nashville, Transit; Tennessee.	−5	47	07.971
25	New Orleans, Transit (1880); Louisiana.	−6	00	16.630
26	Columbus, Transit; Ohio.	−5	31	58.810
27	Cleveland, Transit; Ohio.	−5	26	45.873
28	Detroit, E. Transit of United States Lake Survey Observatory; Michigan.	−5	32	12.170
29	Cincinnati, Dome of Observatory, Mount Lookout; Ohio.	−5	37	41.290
30	Saint Louis, Transit (1881); Missouri.	−6	00	49.163
31	Vincennes, Transit; Indiana.	−5	50	05.928
32	Omaha, Transit; Nebraska.	−6	23	46.000
33	Kansas City, Transit; Missouri.	−6	18	21.370

A comparison of the values of the above table with the corresponding values reached in the first adjustment (of 1880) shows but very slight differences; before reaching Washington the differences do not exceed 0s.001; for Washington the difference is 0s.002, and for New Orleans, the last station of the old adjustment, it rises only to 0s.012 We may, therefore, conclude that our eastern longitudes will not hereafter undergo any (practically) important change due to additions to our system; the only appreciable change might come from additional transatlantic connections. The links via South America are many and their probable errors necessarily somewhat greater than for land lines, hence we do not anticipate any reaction from the closing of such extended circuits on our present longitude stations which stand in such direct connection with Greenwich.

The following table contains the longitudes λ of the remaining station
with the general scheme by a single line only, and others of a subordinate
States and Territories in alphabetical order. The point of reference is the
wise stated:

Name of station.	State.	λ			Name of station.	Stat
		h.	m.	s.		
Eufaula	Ala.	−5	40	33.24	Baton Rouge	La.
Helena	Ark.	−6	02	21.56	Cumberland	Md.
Little Rock	Ark.	−6	09	05.58	Minneapolis	Minn.
San Francisco, Washington Square	Cal.	−8	09	38.34	Natchez	Miss.
					Greenville	Miss.
Los Angeles	Cal.	−7	52	58.65	Vicksburg	Miss.
San Diego	Cal.	−7	48	38.72	Bushnell	Nebr.
Summit	Cal.	−8	01	19.40	Verdi	Nev.
Julesburg	Colo.	−6	49	25.38	Jersey City	N. J.
Denver	Colo.	−6	59	58.20	Cape May	N. J.
Colorado Springs	Colo.	−6	59	16.45	Fort Selden	N. M
Trinidad	Colo.	−6	58	00.20	Albany (dome)	N. Y.
Apalachicola	Fla.	−5	39	56.57	New York	N. Y.
Key West	Fla.	−5	27	13.59	Carpenter's Point	N. Y.
Punta Rasa	Fla.	−5	28	02.74	Travis	N. Y.
Cedar Keys	Fla.	−5	32	07.25	Finn	N. Y.
Saint Augustine	Fla.	–	–	– –	Statesville	N. C.
Pensacola	Fla.	−5	48	50.05	Cincinnati, Mitchel's Obs'y (abandoned)	Ohio.
Mattoon	Ill.	−5	53	32.46		
Springfield	Ill.	−5	58	37.29	Hudson, Western Reserve College	Ohio.
Cairo	Ill.	−5	56	41.02		
Chicago	Ill.	−5	50	27.06	South Point	Ohio.
Indianapolis	Ind.	−5	44	38.51	Philadelphia, old high school (abandoned)	Pa.
Logansport	Ind.	−5	45	24.36	Allegheny Observatory (dome)	Pa.
Burlington	Iowa.	−6	04	25.62		
Des Moines	Iowa.	−6	14	29.04	Burt	Pa.
Cedar Falls	Iowa.	−6	09	47.86	Harrisburg	Pa.
Chetopah	Kans.	−6	20	24.60	Smith's Ferry	Pa.
Oakland	Ky.	−5	45	01.22	Memphis	Tenn
Shelbyville	Ky.	−5	40	53.04	Jellico	Tenn
Falmouth	Ky.	−5	37	20.59	Galveston	Tex.
Paducah	Ky.	−5	54	23.74	Austin	Tex.
Hickman	Ky.	−5	56	46.69	Salt Lake City	Utah
Louisville	Ky.	−5	43	03.51	Burlington (abandoned)	Vt.
London	Ky.	−5	36	21.34	Staunton	Va.
Guthrie	Ky.	−5	48	38.43	Goodson (or Bristol, Tenn.)	Va.
Henderson	Ky.	−5	50	21.77		
Lexington	Ky.	−5	38	01.43	Strasburg	Va.
Louisa	Ky.	−5	30	24.41	Charlottesville, University of Va. (dome)	Va.
Greensburg	Ky.	−5	41	59.76	Covington	Va.
Richmond	Ky.	−5	37	11.41	Seattle	Was
Head of Passes (abandoned)	La.	−5	56	59.8	Kalama	Was

Name of station.	State.	λ			Name of station.	State.	λ		
		h.	m.	s.			h.	m.	s.
Clarksburg	W. Va.	—5	21	21.47	Charleston	W. Va.	—5	26	32.00
Grafton	W. Va.	5	20	06.72	Madison	Wis.	—5	57	36.15
Cameron	W. Va.	5	22	17.50	La Crosse	Wis.	—6	04	59.15
Wheeling	W. Va.	5	22	54.44	Sherman	Wyo.	—7	01	34.21
Parkersburg	W. Va.	—5	26	16.72					
Point Pleasant	W. Va.	—5	28	35.02					
Gauley Bridge	W. Va.	—5	24	51.83	Halifax, Nova Scotia		—4	14	21.41
Martinsburg	W. Va.	—5	11	49.50	Fredericton, New Brunswick		—4	26	32.88

COMPUTATION OF PROBABLE ERRORS OF ADJUSTED LONGITUDES.

The mean error of an observation of weight 1 is found by the expression

$$M = \sqrt{\frac{[p\,\delta\,\delta]}{n}}$$

(where n = number of conditional equations), it may be checked by the relation

$$[p\delta\delta] = -[w\,C]$$

We find $[p\,\delta\,\delta] = .00074895$ and $-[w\,C] = .00074897$, hence $M = \pm\ 0.00597$

The value of the average weight is $\frac{1}{142}$, hence the mean error of an average determination or a difference of longitude $M\ \sqrt{142} = \pm\ 0.0712$ and the probable error of an average determination

$$r = 0.674\,(\pm\ 0.0712) = \pm\ 0^{s}.048$$

which would indicate that our *a priori* assigned probable errors were slightly underestimated.

DETERMINATION OF THE PROBABLE ERRORS OF THE RESULTING LONGITUDES OF WASHINGTON, UNITED STATES NAVAL OBSERVATORY AND OF CAMBRIDGE, HARVARD COLLEGE OBSERVATORY.

In consequence of the somewhat laborious process of computing probable errors of functions of adjusted values, and in the absence of any special need to know the probable errors of all the longitudes, I have here confined myself to those for two principal stations, Washington and Cambridge. The probable errors of these longitudes being known, it is easy to form a close estimate of the reliability of all other resulting longitudes.

Let F equal the function whose probable error is to be computed, then

$$F = f_1\,x_1 + f_2\,x_2 + f_3\,x_3 + \quad . \quad . \quad .$$

where

$$f_1 = \frac{\delta\,F}{d\,x_1} \qquad f_2 = \frac{\delta\,F}{d\,x_2} \qquad f_3 = \frac{\delta\,F}{d\,x_3} \quad \text{etc.}$$

For the numerical terms in the formation of the so-called (by Gerling) Transfer equations* we need the values of

$$[u.\,af] \qquad [u.\,bf] \qquad [u.\,cf] \quad \text{etc.}$$

*For further information on the method, Art. III of the treatise on the adjustment of observations, etc., by T. W. Wright, New York, 1884, may be consulted.

. $+[u.af]=0$
. $+[u.bf]=0$
. $+[u.cf]=0$

]uations, but in the place of C_1 we
e terms $[v.af]$, $[u.bf]$, etc.

l we compute next

. .
. .
. .

· of the function

$;74 \sqrt{\frac{M}{P}}$

th Greenwich via Brest and Saint
;nce

$=f_2=1$

scheme.

$=-73$, all others$=0$; hence the

$+ 48=0$
$-121=0$
$+ 73=0$
$- 73=0$
$0=0$

$x_9+f_{10}\,x_{10}$

$[f]=+44$; all others zero.

..lues of R_1 for

..ington.	Cambridge.
$-.038$	$+.013$
$+.067$	$-.022$
$+.017$	$-.006$
$-.022$	$+.007$
$-.081$	$+.026$
$-.083$	$+.027$
$+.037$	$-.012$
$+.011$	$-.004$
$-.119$	$+.039$
$+.016$	$-.005$

	Values of F_1 for			Values of F_1 for	
	Washington.	Cambridge.		Washington.	Cambridge.
1	− .163	− .162	28	+ .003	− .001
2	+ .735	+ .733	29	+ .003	− .001
3	+ .163	+ .162	30	+ .003	− .001
4	+ .102	+ .105	31	+ .009	− .003
5	+ .102	+ .105	32	− .012	− .002
6	+ .102	+ .105	33	− .011	+ .004
7	+ .102	+ .105	34	− .020	+ .007
8	+ .102	+ .105	35	+ .001	.000
9	+ .664	+ .648	36	+ .038	− .013
10	+ .327	+ .433	37	− .029	+ .009
11	+ .234	+ .247	38	+ .017	− .006
12	+ .234	+ .247	39	+ .017	− .006
13	+ .318	− .102	40	+ .050	− .016
14	+ .337	+ .215	41	+ .022	− .007
15	+ .137	− .045	42	− .022	+ .007
16	+ .134	− .044	43	− .081	+ .026
17	+ .002	− .001	44	− .044	+ .014
18	+ .001	.000	45	− .035	+ .011
19	+ .001	.000	46	− .036	+ .012
20	+ .001	.000	47	− .037	+ .012
21	+ .002	− .001	48	− .011	+ .004
22	+ .002	− .001	49	− .011	+ .004
23	− .002	+ .001	50	+ .119	− .039
24	− .031	+ .010	51	− .103	+ .034
25	− .002	+ .001	52	− .016	+ .005
26	+ .003	− .001	53	− .016	+ .005
27	+ .003	− .001			

In the case of Washington [u. FF] = 108.4 and in the case of Cambridge [u. FF] = 101.5; hence mean error of assigned longitude of Washington

$$\frac{M}{\sqrt{P}} = .00597\sqrt{108.4} = \pm 0^{s}.062$$

mean error of assigned longitude of Cambridge

$$\frac{M}{\sqrt{P}} = .00597\sqrt{101.5} = \pm 0^{s}.060$$

and finally the probable error of the adjusted longitude of Washington = $\pm 0^{s}.042$ and of Cambridge $\pm 0^{s}.041$

LONGITUDE OF DETROIT, MICH.

The value adopted in the United States Lake Survey (see p. 717 of Report of the Primary Triangulation of the United States Lake Survey, Lieut. Col. C. B. Comstock in charge, Washington, 1882) is $5^{h}\ 32^{m}\ 12^{s}.24 \pm 0^{s}.08$; the value found in the present discussion is $5^{h}\ 32^{m}\ 12^{s}.170 \pm 0^{s}.050$, the probable error being a close estimate. Accordingly all Lake Survey telegraphic longitudes depending on Detroit need a correction of $-0^{s}.07$

LONGITUDE OF OGDEN, UTAH.

This station was not admitted into the adjustment of the system, but was reserved for special combination. Using our adjusted values for Detroit, Washington, and Omaha, we have

	h. m. s.	s.
1. $\Delta\lambda$ Ogden and Detroit	1 55 47.471	$\pm$0.068
λ Detroit	5 32 12.170	$\pm$0.050
λ Ogden	7 27 59.641	$\pm$0.084
2. $\Delta\lambda$ Ogden and Washington	2 19 47.515	$\pm$0.067
λ Washington	5 08 12.038	$\pm$0.042
λ Ogden	7 27 59.553	$\pm$0.079
3. $\Delta\lambda$ Ogden and Salt Lake	0 00 24.747	$\pm$0.060
λ Salt Lake $= 6^h\ 23^m\ 46^s.000 + 1^h\ 03^m\ 49^s.111$ $\pm .045 \qquad \pm .009$	7 27 35.111	$\pm$0.046
λ Ogden	7 27 59.858	$\pm$0.076

The weights of these three determinations are practically equal, and we shall adopt the simple mean or $\lambda = 7^h\ 27^m\ 59^s.684 \pm 0^s.07$, the probable error being estimated. The value adopted by the United States Engineers (see p. 55 of Vol. II of Lieut. G. M. Wheeler's Report upon United States Geographical Surveys, Washington, 1877) is $7^h\ 27^m\ 59^s.643 \pm 0^s.027$* Hence all telegraphic longitudes depending on Ogden need an increase of $0^s.04$

JUNCTION OF THE AMERICAN AND EUROPEAN SYSTEMS OF LONGITUDES.

The lines connecting Greenwich, Paris and Brest are common to both, and in strictness these systems should be adjusted as one, but such a proceeding would involve an amount of labor altogether disproportionate to the gain, and another far less laborious process may be adopted with results equally satisfactory. Nor is either system at the present time complete. Our own is increasing in extent and complexity year by year; and with respect to the European system, it has been specially pointed out as desirable that the French determinations should be strengthened by connecting those stations *inter se* which surround Paris (Proceedings Sixth Conference of the International Geodetic Association, 1880, Appendix III, p. 32). If this suggestion be carried out it will bring Brest into more intimate connection with the European system, and thus may slightly react upon our longitudes.

In the Astronomische Nachrichten, No. 2132 (May, 1877), Dr. Albrecht published a preliminary adjustment of the telegraphic longitude-net of Central Europe. This discussion had for its special object to ascertain the degree of accuracy which had then been reached in these measures. He submitted to treatment 22 determinations of differences of longitude, linked together by 11 conditions. The weights allowed (by estimation) range from 1 to 5, and the average correction to any one measure, irrespective of sign, is $0^s.041$; two corrections exceed $0^s.1$ Greenwich is not included in this scheme.

In No. 2265 (June, 1879) he returns to the subject of adjustment of the longitudes connected with the German system, his data in the mean time having increased to 39 determinations between 16 stations, yet his results are stated to be still provisional. The weights assigned range from 1 to 6, according to the estimated value of the operation. The stations Greenwich and Paris are now included, and their difference $\triangle\lambda = 9^m\ 20^s.97$ is given as *observed;* respecting this value see remarks further on in connection with Dr. Bruhns' adjustment of 1880, in which the same slightly

* This probable error is too small, as it takes no account of the probable errors of the base stations, nor of the probable error due to the personal equations. The apparently better accord of the Ogden-Salt Lake value, on p. 55 of the Engineers' work, as compared with the above value (3), is due to the circumstance that a geodetic instead of an astronomical value for the longitude of Washington had inadvertently been used; the value $2^h\ 19^m\ 22^s.740$ there given should have been $2^h\ 19^m\ 23^s.073$, according to our present information.

defective value is employed. Berlin, Bonn and Vienna connect directly with Greenwich and Paris, but Brest is omitted, probably as foreign to the geographical range adopted in this paper. After changing the weights of 6 determinations, the result of his second adjustment gives the value $\triangle\lambda$ Greenwich and Paris $9^{m}\ 21^{s}.025$, with the difference, computed minus observed = + $^{s}.055$ There are six similar differences which exceed $0^{s}.1$ It will be noticed in the next and more complete adjustment that our longitude determination of Greenwich and Paris is not subject to so large a correction as + $^{s}.055$

The latest discussion of the European telegraphic longitudes is contained in the Proceedings of the Sixth Conference of the International Geodetic Association, at Munich, 1880 (Berlin, 1881); Appendix III contains the report of Dr. C. Bruhns, giving an account of the astronomical determinations of positions, and includes a collection of the telegraphic results for longitude executed to date and falling within the limits of the work proposed by the association. The number of measures involved is 59, and between these there subsist 26 conditions. His assigned weights rest upon estimation, and range from 1 to 4. The adjustment shows the probable error of a determination equal to ± $0^{s}.035$ on the average, and there are six corrections to observed values which exceed $0^{s}.1$ The oldest measure admitted dates from 1862, and the latest measures refer to 1878. The triangle Greenwich, Paris, Brest in Dr. Bruhns' adjustment stands as follows:

	Observed λ		Correction	Corrected λ	
	m.	*s.*	*s.*	*m.*	*s.*
Greenwich and Paris	9	20.97	+0.012	9	20.982
Brest and Greenwich	17	57.59	−0.031	17	57.559
Brest and Paris	27	18.51	+0.067	27	18.577

There is some defect in this adjustment, as may be seen by adding the first two numbers and comparing the sum with the third number; in fact, we place little reliance in the adjustment. For the above triangle his fundamental data are not those here accepted as the result of *direct* observation, the value Greenwich–Paris $9^{m}\ 20^{s}.97$, for instance, being partly *adjusted*.*

The above triangle in *our* record and adjustment is as follows:

	Observed λ		Correction	Corrected λ	
	m.	*s.* *s.*	*s.*	*m.*	*s.*
Greenwich and Paris	9	21.000±0.038	−0.048	9	20.952
Brest and Greenwich	17	57.598±0.022	−0.013	17	57.585
Brest and Paris	27	18.512±0.027	+0.025	27	18.537

In the European system Greenwich and Paris are now directly (or nearly directly) connected via Bonn, Berlin, Munich, Vienna and Brest, and when once satisfactorily adjusted, it will probably be found advantageous for us to adopt the corrections demanded by it and readjust the American system with the condition of the longitudes of Brest and of Paris as *fixed*. In the mean time no inconvenience can arise, though it should be borne in mind that in consequence of any future change in the European system of longitudes, as just pointed out, our own longitudes may possibly be affected by a constant correction, and to an amount that may possibly reach $0^{s}.025$

In conclusion, I append the *purely observational* results for the longitude of Cambridge arising from three independent determinations. Since the earlier statements of 1874 were found to need some changes† in order to present the results entirely free of any adjustment, the observed values are taken from the general table of this report. These values are:

I. By Anglo-American cables in 1866, via Foilhommerum, Heart's Content, Calais and Bangor, $4^{h}\ 44^{m}\ 31^{s}.061 \pm 0^{s}.098$

* See Coast Survey Report for 1874, pp. 180–182.

† Clarke's Geodesy, Oxford, 1880, p. 213.

II. By French joined cables in 1870, via Brest and Duxbury, $4^h\ 44^m\ 31^s.065 \pm 0^s.056$

III. By French cable in 1872, via Paris, Brest and Saint Pierre (*a*), $4^h\ 44^m\ 30^s.930 \pm 0^s.058$, and by omitting Paris (*b*), $4^h\ 44^m\ 31^s.016 \pm 0^s.041$

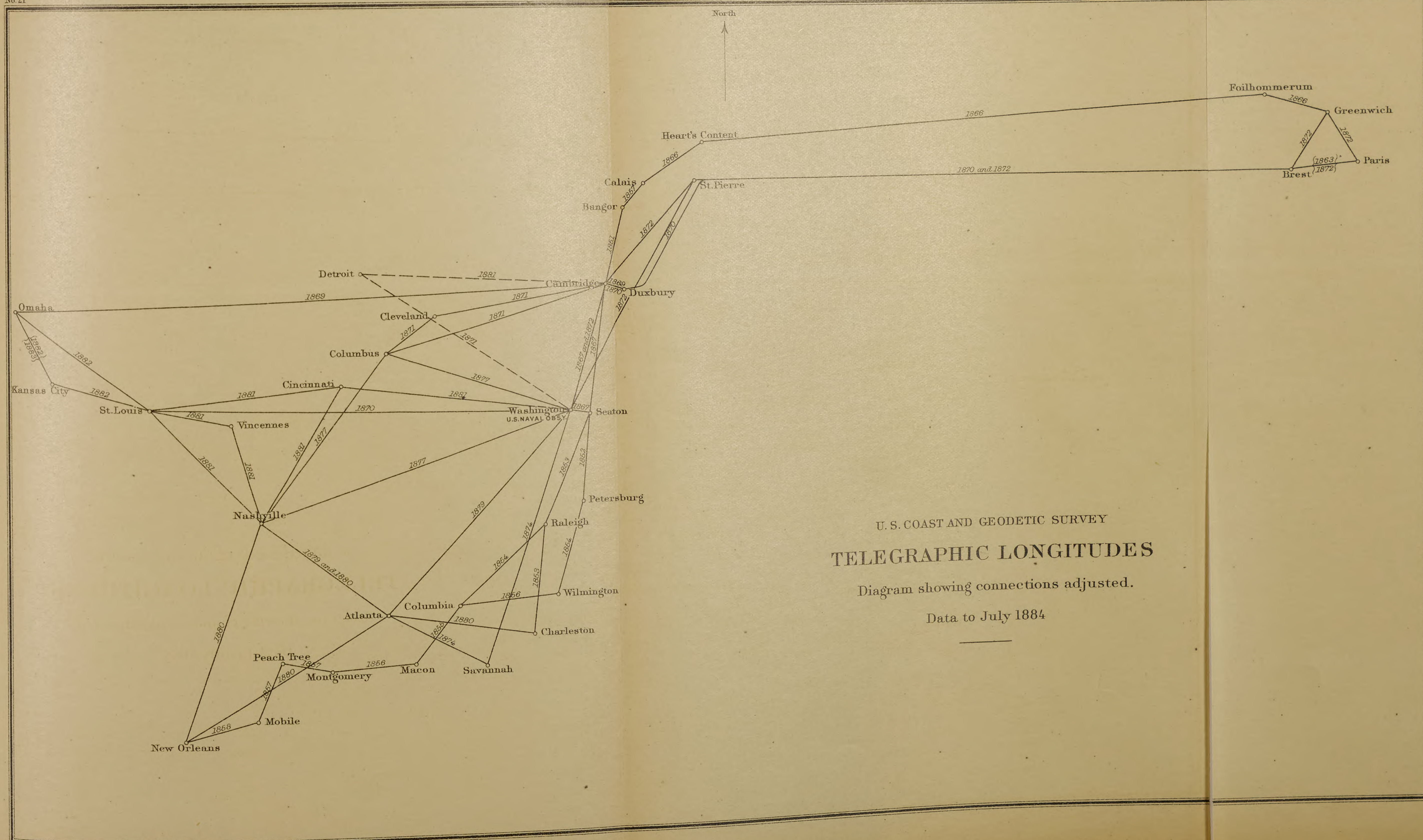
The adjusted value is $4^h\ 44^m\ 30^s.993 \pm 0^s.041$

Considering the special difficulties inseparable from work through long submarine cables, it does not appear to the writer as at all superfluous to add another transatlantic determination to the above by making use of one of the modern cables, and on this side preferably to connect with New York and Cape May, thus adding another link between Cambridge and Washington.

Respectfully submitted by

CHAS. A. SCHOTT,
Assistant.

C. O. BOUTELLE, Esq.,
Assistant in charge Office and Topography.


North
Foilhommerum
Greenwich
Paris
Brest
Heart's Content
St. Pierre
Calais
Bangor
Detroit
Cambridge
Duxbury
Omaha
Cleveland
Columbus
Kansas City
Cincinnati
St. Louis
Vincennes
Washington
U.S. NAVAL OBS'Y.
Seaton
Petersburg
Raleigh
Nashville
Wilmington
Columbia
Charleston
Atlanta
Peach Tree
Montgomery
Macon
Savannah
Mobile
New Orleans
U. S. COAST AND GEODETIC SURVEY
TELEGRAPHIC LONGITUDES
Diagram showing connections adjusted.
Data to July 1884

APPENDIX No. 12.

PHYSICAL HYDROGRAPHY OF DELAWARE RIVER AND BAY. COMPARISON OF RECENT WITH FORMER SURVEYS.

By H. L. MARINDIN, Assistant.

U. S. COAST AND GEODETIC SURVEY,
Boston, Mass., June 30, 1884.

SIR: In accordance with directions from Prof. H. Mitchell, assistant in charge of party, I have the honor to report upon the completion of a comparison of surveys of parts of the Delaware River shown in illustrations Nos. 22 and 23.

Illustration No. 22 shows that part of the river between Old Man's Point and Deep Water Point, including Cherry Island Flats. The surveys compared were executed in 1841 and 1881, both by the Coast Survey.

Illustration No. 23 shows that part of Delaware Bay lying between Reedy Island and Liston's Point; the surveys for the last-named part were executed in 1840–'41, by Lieutenant-Commanding G. S. Blake, U. S. N., and in 1882 by the party of Lieut. H. B. Mansfield, U. S. N., Assistant.

I was directed to take up the comparison of these disconnected localities because the vicinity of Cherry Island Flats has been undergoing artificial changes by dredging which might have affected the surrounding depths; and, with reference to that part given in illustration No. 23, because the vicinity of Reedy Island is generally accepted as the head of Delaware Bay, and because it is proposed to build here a much-needed ice harbor, the location of which may be aided by a knowledge of the changes which have obtained in the forty-one years intervening between the dates of the surveys.

The illustrations indicate by shading lines differences for every 3 feet in depth. The increase of depth is denoted by the lines in *blue ink*, and the shoaled parts by the black lines. The change of 0 feet to 3 feet by the lightest shading; that of 3 feet to 6 feet by the next heavier shading, and so on. The blank spaces indicate no change of depth.

To maintain uniformity between the data given in previous reports* by Prof. Mitchell and myself, we have retained the divisions by number of cross-section and nautical miles from Fort Mifflin, as measured along the axis of the stream. This enables us to compare each consecutive mile.

The comparison on illustration No. 22 covers an area of 6.36 square nautical miles and discloses many changes in the depth. In the instance of the general shoaling over the Cherry Island Flats, it corroborates the results obtained in previous comparisons, *i. e.*, that the shoals have become shoaler. Over a large area of the flats the decrease of depth attains a maximum of 11 feet, and as this was the least depth found on them in 1841, we have now the apex of the shoal bare at low water.

The deepest part of the reach under comparison, in the proximity of Deep Water Point, also shows unmistakable shoaling: that this narrow section with an area of cross-section of only 116,796 square feet—much below that which would be expected at this distance from the mouth—should be in process of being reduced is anomalous, and Professor Mitchell, in previous studies of this locality, has found that Deep Water Point falls out of line in the discussion of the physical conditions of the Delaware.

*See Appendix No. 15 to the Report for 1882 and No. 8 to that for 1883.

He is of the opinion that accurate observations of the currents and tides might possibly give a clew to these irregularities. The mean area of cross-section for the mile which includes Deep Water Point is 127,868 square feet, while the adjoining mile, both above and below, gives 136,000 square feet as the measure for this part of the river.

In order to be able to compare small areas of the stream, the river is divided into mile reaches; these are denominated by large letters on the illustrations, and begin at mile O, 14 miles from Fort Mifflin; this mile gives an excess of excavation over shoaling of 2,296,282 cubic yards, which probably has moved down-stream. The whole volume of deepening was 2,490,725 cubic yards, and the shoaling 194,443 cubic yards, which gives the excess noted above. This excess, if spread out evenly over the 883 acres within the mile limits, would give an increase of depth of 1.61 feet. It may be noted that the conditions, within this mile, are very favorable to the maintenance of the channel depths, and that the fair-way occupies the width of the river, with an indication of the formation of Cherry Island shoal at its lower limit.

The next mile, P, presents also an excess of deepening of 880,401 cubic yards, which occurred chiefly in the deeper parts of the channel. On the shoal which begins to show itself at the upper limit, the shoaling is decided, showing a maximum difference of 11 feet. This was the minimum depth found on this shoal in 1841. In 1881, at the date of the last survey, we find bare spots at low water stage. Yet, notwithstanding this large accumulation on the shoalest part of the flats, the indications are that the average depth—within mile P—has increased 0.5 foot. The movement of material within this mile was 2,383,864 cubic yards of excavation, and 1,503,463 cubic yards of shoaling, from which the average increase of depth given above is derived.

Since the greater part of the material removed from mile O must have passed down stream through P, and as P shows still an excess of deepening, we may find that this material, re-inforced by the amount from mile P, has in great measure lodged in the lower reach at and above Deep Water Point.

In the next, mile Q, there has been an excess of shoaling of 850,688 cubic yards, lodged principally on the apex of Cherry Island Flats, and as a large volume of material has been dredged on the west side of the flats for a ship channel, this excess should be increased by that amount in order to show the actual movement. The changes were 1,731,472 cubic yards of deepening and 2,582,160 cubic yards of shoaling, from which excess of shoaling an average decrease of 0.38 foot in the depth is obtained.

Mile R, next below, gives an excess of deposit of 1,283,041 cubic yards distributed fairly evenly over the area inclosed, with the exception of the vicinity of the mouth of Christiana Creek, where a large accumulation may be traced. The southern end of the dredged channel through Cherry Island Flats, from which a large volume has been excavated, falls within this mile, so that the actual volume of shoaling should exceed that given above. The average decrease of depth is 0.65 foot.

The following mile, S, which is the last on the tracing, shows the largest accumulation of deposit, amounting to 4,230,169 cubic yards, or nearly 87 per cent. of the entire shoaling within the 5 miles. This deposit gives an average decrease of depth of 3.05 feet, which would be alarming were it not that there is still a clear water-way with 44 to 48 feet in the channel at mean low water. The changes noted were 160,236 cubic yards of deepening, and 4,390,404 cubic yards of shoaling.

If we now observe the entire change within the 5 miles we find an excess of 3,187,215 cubic yards of shoaling; adding to this sum 1,624,741 cubic yards* dredged by the United States Engineers on the Cherry Island Range, and we find 4,811,955 cubic yards of material lodged within the area represented on illustration No. 22, with, however, the bulk of this shoaling within mile S, in the vicinity of Deep Water Point.

The movement of the shore-line was not ascertained, owing to the omission of sections of this line from the sheets of the survey of 1841.

The comparison of *thalweg* depth through the channels east and west of Cherry Island Flats presents a favorable outlook. In 1841, before the present dredged cut through the flats was begun, the mean average *thalweg* depth along the Delaware shore, between a point opposite

* These data were furnished by Maj. W. H. Heuer, United States Engineers. The dredging began in October, 1879, and ended in October, 1883.

Dupont's Landing and the mouth of Christiana Creek, was 23.6 feet, with a minimum depth of 19 feet about on the site of the range-cut. In 1882, after the completion of the dredged channel, the *thalweg* depth was 25.5 feet, with a minimum of 23.5 feet.

The western channel also shows an improvement throughout. From a point opposite Old Man's Point to the deep water below the flats the *thalweg* depth was 24 feet in 1841, with a minimum depth of 19 feet. In 1881 the average *thalweg* depth between the same points was 25.5 feet, with a minimum depth of 20 feet. All depths given refer to mean low-water stage.

The inference can be drawn from the above results of the comparison of depths in the vicinity of Cherry Island Flats, that of the two rival channels around the flats the eastern channel would have been the better one to have chosen for artificial improvement by dredging. This is strongly suggested by the fact that without any aid outside of natural forces the eastern channel has gained in depth since 1841, notwithstanding the adverse condition of opening a rival channel by the removal of 1,500,000 cubic yards of material. The vicinity of the dredged cut also shows considerable shoaling by the motion of the 18-foot curve to the edge of the cut.

This closes the discussion of the results given graphically on illustration No. 22. These results are given in a condensed form in Table No. 1 which follows:

TABLE No. 1.—*Changes in Delaware River between* 1841 *and* 1881.

[See illustration No. 22.]

Miles from Fort Mifflin.	Letter.	Between cross-sections—	Area in acres.	Volume of—		Excess of—		Change in mean depth.	
				Deepening.	Shoaling.	Deepening.	Shoaling.	Increase.	Decrease.
				Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Feet.*	*Feet.*
15	O	299 to 318	883.0	2,490,725	194,443	2,296,282	....	1.61	....
16	P	318 to 337	1,070.8	2,383,864	1,503,463	880,401	....	0.50	....
17	Q	337 to 357	1,370.7	1,731,472	2,582,160	....	850,688	....	0.38
18	R	357 to 377	1,217.5	1,289,344	2,572,385	....	1,283,041	....	0.65
19	S	377 to 398	856.9	160,235	4,390,404	....	4,230,169	....	3.05

In the accompanying illustration, No. 23—comprising the head of Delaware Bay—the comparison begins at cross-section 574, 32 miles from Fort Mifflin; this cross section crosses the southern point of Reedy Island and ends just above the mouth of Alloway's Creek. The first mile, marked H, ends at cross-section No. 586 and contains 2,407 acres, within which we find an excess of shoaling of 2,236,227 cubic yards, which, if spread out, decreases the mean depth by 0.57 feet. This shoaling may be due in part to the erosion of the shores, which have retreated inland along both the New Jersey and Delaware side, about 285 feet for the former and 126 feet for the Delaware shore. The mean width of the stream, for the 5 miles shown on illustration No. 23, has therefore increased 411 feet. The decrease of depth has obtained principally in the deep parts of the channel-way and along the Delaware shore.

The south end of Reedy Island, included within the limits of this mile, shows a large decrease of superficial area since 1841, equal to 71 per cent. Should the loss continue at this rate, the south point, including the present site of the light-house, will have disappeared in the year 1900.

The loss of area for the whole island is, however, much below that given for the south point. In 1841 the island had an area of 152.2 acres; in 1882 the area was 116.7 acres, which shows a loss of 35½ acres or 23 per cent. At this rate the island would still be in existence 135 years.

In a chart of the Delaware published in 1670, Reedy Island is shown and called Rizt Island. The scale of the chart being very small, no comparison of area can be made; but in a survey of Des Barres, made in 1779, the island is called Reedy Island, and has an area of 288 acres. This area seems large, and if not actually measured might be accounted for by the tendency to exaggerate objects when sketching them. This is mentioned merely to show that the island has been wasting away since our knowledge of its existence.

In the mile between sections 586 and 597, marked I, the shoaling again exceeds deepening by 2,563,511 cubic yards, which reduces the depth for this mile 0.56 foot. Four hundred and eighteen

acres show no change out of a total of 2,809.3 acres. The shoaling is again found mainly in the deepest part of the channel and occupies nearly the whole width between the 18-foot curves.

The next mile, J, has an area of 2,638.9 acres, showing a still greater volume of shoaling than the preceding reach. The excess of shoaling is 4,418,311 cubic yards, which reduces the mean depth by 1.04 feet. An inspection of the illustration discloses that the shoaling extends nearly throughout the width of the bay, and that it is the heaviest in the channel where a maximum loss of 6 feet may be noted.

The next area, mile K, between sections 608 and 619, begins to show a large decrease in the volume shoaled, although still in excess of the volume excavated. The area within this mile is 2,321.5 acres, over which the excess of shoaling of 923,226 cubic yards gives a decrease of mean depth of 0.25 foot. Only 96.6 acres give no change of depth. The accumulation appears to have been heavy on the west side of the ship channel, while the eastern half shows a decided deepening which also obtains along the Jersey shore.

Mile L, between sections 619 and 631, is the first which presents an excess of deepening over filling; this increase of depth has taken place largely in the channel, while the Delaware side shows a decrease of depth. The depths along the Jersey shore also show better water. The area within this mile is 2,360.5 acres, with an excess of deepening of 2,045,125 cubic yards, which gives a mean increase of depth of 0.54 foot. Two hundred and thirty-five acres gave no change of depth.

A recapitulation of the changes exhibited in illustration No. 23, which represents 15 square nautical miles of the head of Delaware Bay, gives 23,044,616 cubic yards of shoaling, which if spread out over the area where shoaling has occurred gives an average decrease of 2.35 feet in the depth.

If we compare the above aggregate amount of shoaling with the volume of 14,948,466 cubic yards excavated, we find an excess of filling of 8,096,150 cubic yards, which would give an average decrease of 0.4 foot in the depth for the five miles in comparison. The erosion of the shores, amounting to 4,234,389 cubic yards, doubtless accounts for part of the above filling. This, however, still leaves a balance of 3,861,761 cubic yards of foreign material supplied from elsewhere; but as the reach above Reedy Island, as far as Fort Delaware, shows an excess of deepening over shoaling, we may infer that the supply has come from up-stream, and, as in this case, the volume of supply is greatly in excess of the amount found to have lodged within the limits under comparison, we may look for further deposits toward the capes of the Delaware.

The following table No. 2. presents the changes exhibited graphically on illustration No. 23:

TABLE No. 2.—*Changes in Delaware River between* 1840 *and* 1882.

[See illustration No. 23.]

Miles from Fort Mifflin.	Letter.	Between cross sections—	Area in acres.	Volume of—		Excess of—		Change in mean depth.	
				Deepening.	Shoaling.	Deepening.	Shoaling.	Increase.	Decrease.
				Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Feet.*	*Feet.*
33	H	574 to 586	2,407.7	1,837,051	4,073,278	....	2,236,227	....	0.57
34	I	586 to 597	2,809.3	2,002,046	4,565,557	....	2,563,511	....	0.56
35	J	597 to 608	2,638.9	2,308,885	6,727,196	....	4,418,311	....	1.04
36	K	608 to 619	2,321.5	3,761,986	4,685,162	....	923,226	....	0.25
37	L	619 to 631	2,360.5	5,038,548	2,993,423	2,045,125	....	0.54	....

The results given in these pages are derived from a vast amount of work which cannot appear. The determination of areas with the planimeter and the computations of volume were made by Mr. J. A. Sullivan, Coast and Geodetic Survey, under the direction of the chief of party.

Respectfully submitted.

HENRY L. MARINDIN,
Assistant Coast and Geodetic Survey.

J. E. HILGARD, Esq.,
Superintendent Coast and Geodetic Survey.

APPENDIX No. 13.

GEOLOGY OF THE SEA-BOTTOM IN THE APPROACHES TO NEW YORK BAY.*

BY A. LINDENKOHL, COAST AND GEODETIC SURVEY.

During the survey of the sea-approaches to New York in the years 1842 and 1844, specimens of sea-bottom were collected while soundings were in progress. The samples were examined under the direction of Professor Bache by Assistant L. F. Pourtales of the Coast Survey office, and by Prof. J. W. Bailey, of West Point, N. Y., and the results of the analyses were published as Appendix No. 11 to the Coast Survey Report for the year 1869. The investigations by these naturalists attracted attention and ended in opening the way to a field of scientific inquiry, which, at this time, is cultivated by men eminent in such researches in all the leading nations. Neither of the naturalists here named is now living.

Within the last five years, minute hydrographic surveys have been made in the same locality. Some collateral information also has been furnished by the Geological Survey of New Jersey under the direction of Prof. George H. Cook. We are thus enabled to invest deductions with increased precision, and to extend inquiry beyond the limits to which Assistant Pourtales restricted himself.

The sea-bottom off the entrance to New York Lower Bay is characterized by features peculiar to that region. These include: (1) A well defined submarine valley; (2) an area of clay bottom extending about one hundred miles seaward; (3) a deep ravine at the edge of the continental slope.

The features here specified will be separately described. (See illustration No. 24.)

Submarine valley.—The early survey of the sea-approaches to New York developed the existence of a series of "deep mud holes" lying in a straight line off the entrance. These it was supposed might serve as guides to mariners, but no special significance was attached to the "mud holes" until Professor Dana, from a study of the Coast Survey soundings, showed that they lay in the course of a valley-like depression which had the right position to have been, in a period of higher level, the continuation of the Hudson River channel. When these views were communicated to the Coast Survey office, these mud holes were at once recognized as indications of such a channel, and it was surmised that they actually formed a continuous channel instead of being separated. The last survey has developed the existence of this channel; and thus the question is opened, whether this channel was produced by a break in the strata, as was the upper channel of the Hudson, or by the current of a river seeking an outlet to the ocean. The following facts bear upon the question:

The first indications of the channel are found ten nautical miles east by south off Sandy Hook, at a depth of nineteen fathoms. After following a southerly course for about ten miles, the channel takes an easterly turn in the next five miles: from the distance of fifteen miles (twenty miles in a direct line from the Hook) it maintains a straight course (60° SE.) to its bar, which is seventy-five miles from the Hook.

From the head of the channel to the bend, the top of the banks remains at about an even level of eighteen fathoms depth, while the channel increases in depth from nineteen to thirty-six fathoms. The average slope of the banks is one degree, and the width of the inclosed channel from three-

*This paper was read by the Superintendent at the meeting of the National Academy of Sciences in April, 1885, and was first published in the American Journal of Science for June, 1885.

quarters of a mile to a full mile. In the bend, this slope is increased to three degrees, and the width contracted to one-eighth of a mile.

The banks maintain the same height on both sides, and are, as also is the bottom, composed of a sandy clay overlaid by a crust of sand and gravel which spreads continuously over the adjacent flats. This clay is very uniformly described by the surveyors as "blue clay" in the upper channel to the distance of forty miles from the Hook, and "green mud" in the lower channel. The bar (at seventy-five nautical miles from the Hook) is composed of fine sand. At the distance of eighty-five miles the channel reappears as a deep ravine and it will be described separately. The cross sections of the channel, at intervals of ten miles, starting from Sandy Hook and taken from the recent survey, are here given.

Distance.	Depth of channel below sea-level.	Distance from top of clay banks to sea-level.	Height of banks.
Nautical miles.	*Fathoms.*	*Fathoms.*	*Fathoms.*
10	25	17	8
20	35	20	15
30	37	22	15
40	42	27	15
50	41	30	11
60	43	36	7
70	43	38	5
(75)	(41)	(39)	2
80	43	43	0

From this exhibit we may infer that the channel has been produced by erosion and that its present shape is due to the action of flowing water. The mud brought up by the lead has not been deposited upon the sea-bottom by precipitation, but is the actual soil, which is a stratum of clay which must have a thickness of over ninety feet.

This sandy clay is believed to be identical with the Tertiary "sandy clay strata" of the New Jersey Geological Survey, which underlies nearly the whole of the peninsula of lower New Jersey.

The disappearance of the submerged valley at a less depth than nineteen fathoms must be attributed to the obstructive action of Sandy Hook bar. By taking this depth as the greatest ever reached by the channel over the bar near Sandy Hook we can form an estimate of the geological age of this bar.

Professor Cook, in a statement made before the Riparian Commission of New Jersey, November 17, 1883, estimates the present rate of subsidence of the coast of New Jersey at about two feet in a hundred years. At this rate the decrease of depth from nineteen fathoms to four fathoms, which is about the present mean depth of the New York bar, would cover a period of 4,500 years.

The transfer *per saltum* of a bar at the depth of forty-one fathoms and at a distance of seventy-five miles from the Hook to one of nineteen fathoms depth, and in the immediate vicinity, however, cannot well be explained upon the theory of such a gradual and moderate subsidence as is believed to be going on at the present time.

The State geologist, Professor Cook, assuming a mean dip of twenty-five feet to the mile for the marl beds, has indicated lines of strike upon his geological map, showing the depth below sea-level of the red sand bed (a subordinate stratum of the Cretaceous marl formation) and the lines A and B on illustration No. 24 are such lines for the depths, respectively, of 250 feet and 1,040 feet. These lines produced to the submerged channel strike the top of the clay bank at points the respective depths of which are 108 and 162 feet below the ocean level.

The great difference in dip (790 feet against 54 feet) may be accounted for by supposing that the top of the clay bank does not coincide with the line stratification (its slope being about two feet to

the mile), or there may be a flattening out of dip toward the sea. And, again, the sandy clay bed may not rest conformably on the formations which crop out on the dry land.

In the geological surveys of Pennsylvania and New Jersey the terminal moraine was accurately traced through these two States, and the sketch shows its course from the valley of the Alleghany in Western New York, eastward and southward to New York Bay. The line as there shown was taken from a map by Professor Lewis in the American Journal of Science, 1884, and from the geological map of New Jersey, 1882. It will be seen at a glance that this line and the submerged valley of the Hudson form a continuous line, and this coincidence suggests that this valley stands as a mark of the limit of the glacial drift and as one of the "great waste-weirs of the melting glacier," to use an expression which Professor Lewis applies to the Lehigh River. The range of hills which traverses Long Island from the New York Narrows to Montauk Point has been recognized as a well-developed glacial moraine, and Professor Cook has established its lateral connection with the New Jersey moraine by way of the southern part of Staten Island. Now, if the contemporaneous existence of these two moraines could be proved, it would follow that the south end of Staten Island was the most advanced point of the glacier. Professor Chamberlin has very recently (in a contribution to the annual report of the United States Geological Survey, 1882–'83) made the relative ages of these two glaciers the subject of a careful study. For our present purposes it will suffice to state that the Long Island moraine, by reason of its great boldness, which implies a period of powerful glacial action, bears a greater resemblance to the more northerly moraines of the interior than to the terminal moraine which stands as the extreme advance of a gradually receding glacial drift. This circumstance alone warrants the assumption that the terminal moraine must be looked for to the southward of Long Island.

Clay bottom.—Assistant Pourtales drew attention to a large area of muddy bottom off the eastern end of Long Island, and remarked also upon the scarcity of remains of animal life in the specimens of bottom from this region. That muddy bottom zone is interposed between the wide sand belt which skirts the coast and the deep-sea ooze which is of calcareous nature and which covers all the deeper bottoms of the ocean. By careful study of the soundings, including those recorded by the United States Fish Commission, we are enabled to trace the outline of this formation. It is triangular; the base D E (see illustration) coincides nearly with the line of 1,000 fathoms and reaches from the latitude of Cape Charles to the longitude of Cape Sable. The apex (F) lies about ten miles southeast of Block Island, but a narrow strip of muddy bottom can be traced still farther north, nearly to the western end of Martha's Vineyard.

Assistant Pourtales says (Coast Survey Report for 1869, Appendix No. 11), "The mud or ooze had its origin probably in the Tertiary formation of which we see only the remnants in the cliffs of Gay Head, and in a few localities of small extent on the coast of Massachusetts, as at Marshfield or elsewhere. * * * A similar sea-bottom is found in the so-called mud holes off the entrance to New York. They are depressions below the general depth of the surrounding bottom, filled with mud." These expressions do not render it clear to me whether he considered this mud to be sediment or true soil; but judging by the uniformity and the magnitude of its range, since the greater part if not the whole of the mud in question is either clay or corroded clay,* we recognize in it the traces of a great geological formation having a vertical range of nearly six thousand feet. The sea-bottom within this area may contain the outcroppings of strata of various compositions and of different ages, but these strata must be assumed to be always more or less argillaceous. The shoaler soundings generally show a strong admixture of sand, while the deeper ones appear as purer clays. At about the depth of 1,000 fathoms the clay gives way to the globigerina ooze; but in some instances clay has been found by the Fish Commission at depths over 1,500 fathoms.

In view of the fact that in a coast region the distribution of "sand" and "mud" bottoms is very often the result of ocean currents, it appears proper to define the extent to which such currents may have affected the limits of our "clay region." We may freely admit that, in moderate

* The fact that the specimens of sea-bottom brought up from this region, instead of being recognized as clay, nearly always have the character of a green sandy mud, may be accounted for, partly by the difficulty of penetrating hard clay and bringing up large quantities of matter with the sounding apparatus in general use, and partly by the supposition that in regions where there are no strong currents, clay bottoms will always be found affected by the solvent power and chemical action of sea-water upon their components.

depths, currents may disturb and shift the material of the bottom and may also change its mineral composition by the introduction of sediment washed out to sea, but such changes cannot take place at great depths nor at great distances from the coast and could have affected but a very limited part of the clay bottoms. The only agency which could change the geological structure of the sea-bottom at the depth of the main part of the clay region, we take to be precipitation of very fine material held in suspension by the sea-water; but the effect of such precipitation would be to obliterate existing geological distinctions rather than to render them more apparent.

A line drawn from Trenton to Jersey City separates the clay region from the red sandstone region. This line is about one hundred and fifty miles from the curve of one thousand fathoms. Hence if we assume these two lines to be on one plane of stratification, the dip of the strata would be forty feet to the mile. It appears quite plausible to assume that the dip of pliable strata which is found to be decreasing in the coast region should show an accelerated increase when it approaches the continental slope.

It has been suggested by Professor Dana, and is so stated in Dana's Manual of Geology, 2d edition, p. 537, that the lower limit of the New England part of the terminal moraine probably coincided with the outline of the deep-water slope, about 80 miles south of Long Island and outside of Saint George's Shoal. Now, the clay bottom region being bare of drift, we can safely assume that the lines F D and F E indicate the extreme limit of glacial drift on this part of the continent. The thickness of the cover of diluvial drift in the vicinity of the submerged valley appears to be at the utmost about 60 feet.

The Hudson River fiord.—The deep ravine mentioned above as one of the remarkable features of the sea-approaches to New York lies in a nearly straight continuation of the submarine channel, and reaches from the outer end of the bar already mentioned, or about 85 miles to seaward from Sandy Hook, to the edge of the continental slope, at a distance of about 105 miles from the Hook. This ravine is about 25 nautical miles long and 3 miles wide. It commences with a depth of about 60 fathoms below the ocean's surface, which increases to 200 fathoms within the first mile; the greatest depth, 474 fathoms, is close to its outlet. This outlet to the ocean is in the shape of a bar, with a depth of about 200 fathoms. For half its length, from its middle to the bar, this ravine maintains a vertical depth of more than 2,000 feet, measuring from the top of its banks; these banks have a nearly uniform slope of about 14°. It remains to be stated that the bottom and the sides of the ravine are composed of a green sandy mud, and the adjacent flats, unlike those of the submerged channel, show the same material.

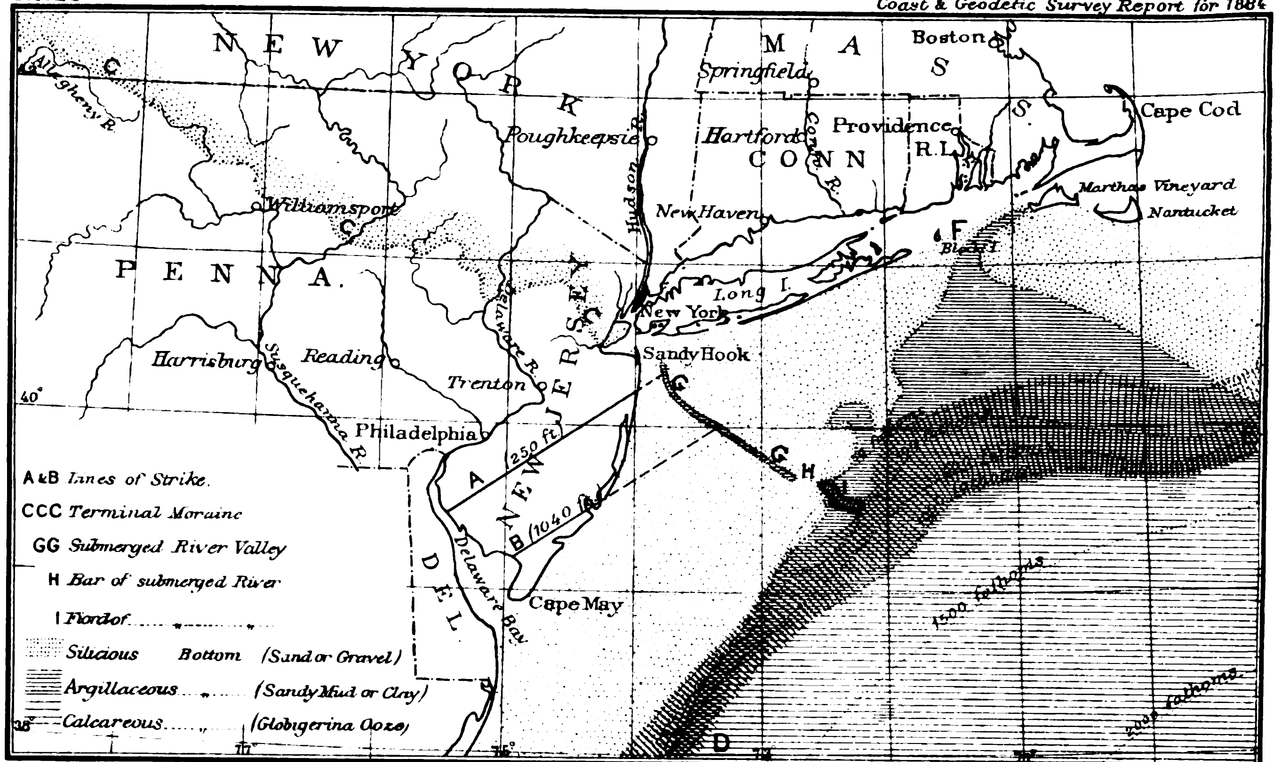
The absence of signs of violent action in the region of this depression precludes the supposition that it is a fissure; on the contrary, its position at the lower limit of the glacier, its shape and its direction, render probable the supposition that it belongs to the class of fiords so common to higher latitudes. If we so conclude, the question cannot be avoided—why is the continuity of the submerged channel interrupted by a bar? The borings at Cape May, Atlantic City, and elsewhere along the New Jersey sea-border, carried down to depths of 200 feet or more, do not show any harder strata than clay. Hence there is no reason to assume that this bar was induced by a rocky obstruction. It appears more plausible to suppose that the fiord belongs to an earlier time when the river made its channel to the sea through ice obstructions, and that the submerged channel farther up is of a later period, when the passage to the ocean was free, and the régime of the river was well established.

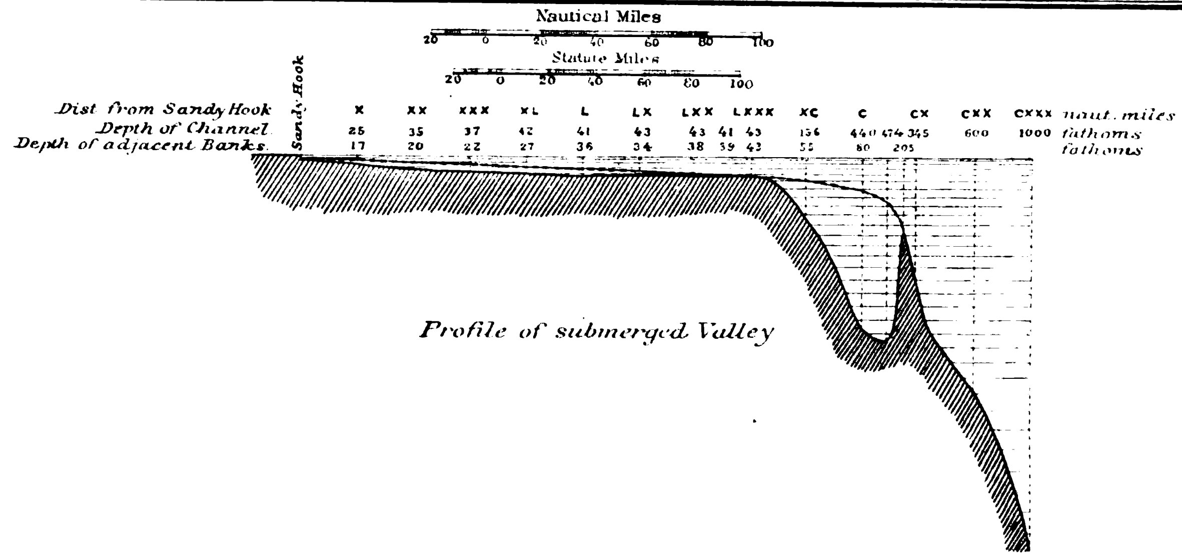
Geology of the Sea Bottom in the Approaches to New York Bay.

By A. Lindenkohl.

No. 24

Coast & Geodetic Survey Report for 1884





Profile of submerged Valley

APPENDIX No. 14.

DETERMINATIONS OF GRAVITY WITH THE KATER PENDULUMS AT AUCKLAND, NEW ZEALAND; SYDNEY, NEW SOUTH WALES; SINGAPORE, BRITISH INDIA; TOKIO, JAPAN; SAN FRANCISCO, CAL.; AND WASHINGTON, D. C.

By EDWIN SMITH, Assistant.

WASHINGTON, *May* 1, 1884.

DEAR SIR: I have the honor to submit the following report of the pendulum work executed by the party under my charge, in conformity with your instructions of September 8, 1882.

A party going to Auckland, New Zealand, to observe the transit of Venus in December, 1882, an opportunity was afforded to make valuable pendulum observations at that place and other points at a comparatively small additional expenditure of money.

During 1881–'82, Major Herschel, R. E., swung the three invariable Kater pendulums, Nos. 4, 6 (1821), and 11, at Kew, Greenwich, and Laugham, England, and at Washington and Hoboken. United States, in order to form a connection between the English and American pendulum work, On completion of these observations the pendulums were loaned to the United States Coast and Geodetic Survey. Nos. 4 and 6 (1821) are the pendulums used in the Great Trigonometrical Survey of India, and all three have most important places in the pendulum observations of the present century. It seemed to you in every way most desirable to use these pendulums on the proposed expedition, and thus add important data to that already existing, and strengthen the connection between American pendulum work and that executed in other countries. Having been appointed to the charge of the United States Transit of Venus party to New Zealand, these pendulums were turned over to me by Prof. C. S. Peirce, Assistant Coast and Geodetic Survey, in whose care they had been since Major Herschel's departure.

Prof. H. S. Pritchett, of the Washington University, of Saint Louis, was appointed Assistant Astronomer, and Augustus Story, of Boston, and Gustave Theilkuhl, of Washington, as photographers in the Transit of Venus party.

We sailed from San Francisco on September 24, 1882, and arrived at Auckland, New Zealand, October 15. After the Transit of Venus and pendulum work at this station was completed, the two photographers returned to the United States. Accompanied by Prof. H. S. Pritchett as Acting Assistant in the Coast and Geodetic Survey, I visited the following places at which the pendulums were swung, viz: Sydney, New South Wales, in January, 1883; Singapore, Straits Settlements, British India, in March; Tokio, Japan, in April and May; San Francisco, Cal., in June.

It was intended, also, to swing these pendulums at Batavia, Java, and at Hong-Kong, China, but these stations had to be given up from want of both time and funds.

The pendulums were finally again swung in Washington, during March and April, 1884, where I was assisted by Mr. H. Farquhar, of the Coast and Geodetic Survey, who had assisted Major Herschel in his observations at Washington and Hoboken in 1882.

INSTRUMENTS.

The party was furnished with the following outfit:

Meridian telescope* No. 13, Coast and Geodetic Survey—focal length, 26 inches; aperture of objective, $1\frac{3}{4}$ inches; power, 60.

* Combination of transit and zenith telescope.

Chronograph No. 5, Coast and Geodetic Survey.

Sidereal break circuit chronometer, Bond & Sons, No. 387, Coast and Geodetic Survey.

Sidereal break-circuit chronometer, Negus No. 1539, Transit of Venus Commission.

Mean time break-circuit chronometer, Negus No. 1490, Transit of Venus Commission.

Green cistern barometer, Coast and Geodetic Survey.

The following Kater pendulums and apparatus turned over to the Coast and Geodetic Survey, by Major Herschel, R. E., viz:

1. A clock with gridiron pendulum, by Shelton, of London, marked R. S. and 34 on the face, and No. 2* on the plate at back, which carries the supports of the pendulum. The clock is accompanied with Herschel's disks for observing coincidences.

2. Kater invariable pendulums Nos. 4, 6 (1821), and 11, and a dummy. Each pendulum is provided with a carriage and planes with corresponding number.

3. A copper vacuum chamber with glass bell for top, air-pump, &c.

4. Wooden frame-work support and accessories.

5. Telescope for observing coincidences.

6. Lens for bringing the image of clock pendulum in same plane with tail-piece of the detached pendulum.

7. Thermometers by Adie, Nos. 3, 4, 714, and 715. Nos. 714 and 715 were attached to the dummy, as in the Indian work.

8. Siphon barometer, by Adie. A quantity of moisture having accumulated in the glass tube, a new one was obtained from Green, of New York, and used at Auckland, Sydney, and Singapore. At Tokio it was found broken, and the old tube was broken while trying to drive the moisture and air out. At Tokio and San Francisco observations were made at full pressure of the atmosphere, the Green cistern barometer being used. A new siphon tube was obtained from Green for the Washington observations.

A detailed description of these pendulums and apparatus is given in Vol. V of the Great Trigonometrical Survey of India, and it is thought unnecessary to repeat it here.

METHOD OF OBSERVATION.

The work with these pendulums being purely differential, and intended for comparison with the observations made by Major Herschel, his methods were adopted as nearly as practicable.

The pressure in the vacuum chamber was kept such that the density would be nearly that of air at 32° F. under a pressure of 26 inches.

The pendulum was started with an arc of about 75′ (1.1 inches), and swung for about six hours, when the arc was about 8′ (.12 inch). A coincidence, the arc, temperature, and pressure were observed at the beginning and end of the set, and also an occasional intermediate coincidence. Four such sets were observed in the position called M (marked face towards observer), and four sets in position called P (marked face from observer). Thus each pendulum was swung forty-eight hours, twenty-four in each position. The observations with the three pendulums at each station, except Washington, were completed in 144 to 168 consecutive hours. At Washington double the number of observations were made.

In observing coincidences the disappearance and re-appearance of the Herschel dots were noted on only one side of the tail-piece of the pendulum—always the apparent right. The observer called "*tip*," and the time was noted and recorded by an assistant standing by the clock. At Washington we had no recorder, and as the face of the clock could not be seen by the observer, the time of coincidence was noted with mean-time chronometer, Bond & Sons, No. 196, and from the comparisons of time-pieces the R. S. Clock times of coincidences were deduced.

The coincidences were observed by Prof. H. S. Pritchett or myself at all the stations except Washington, where Mr. H. Farquhar, of the Coast and Geodetic Survey, took part in the observations in place of Professor Pritchett.

* In the inventory received from Major Herschel with this apparatus, it stated that the number on the plate at back which carries the supports of the pendulum is 1. When this clock was unpacked at the Coast and Geodetic Survey Office, in January, 1884, the case was so much damaged that a new one was made, and it was then discovered that the number is 2.—E. S.

METHOD OF REDUCTION.

As I have no definite knowledge of the precise method of reduction adopted by Major Herschel, I have practically adopted that given in Vol. V of the Great Trigonometrical Survey of India. In this report are given all the data necessary to make a complete new reduction, or additional corrections, as may be deemed necessary. The results are or may be made strictly comparable with all observations heretofore made with these pendulums.

The preliminary number of vibrations R′ in a mean solar day corresponding to each set was computed as follows:

$$R' = R - \frac{2\,m\,R}{N}$$

N being the interval in clock seconds between the first and last coincidence, and m the number of coincidence intervals in the set, and R the number of vibrations made by the clock pendulum in a mean solar day. The rate of the clock having been obtained in sidereal time except at Washington.

$$R = 86636.555 - \left(r + \frac{r}{365}\right)$$

and for Washington $\qquad R = 86400 - r$

R′ then received three corrections.

1. Reduction to infinitely small arc.

$$\text{Correction} = R' \left(\frac{D-d}{16\,r\,D}\right)^2 \left\{(a+b)^2 - \frac{(a-b)^2}{3}\right\}$$

D = 84 inches, being the distance of the objective of the telescope from the scale by which the arcs were measured, d the distance of the tail-piece of pendulum from this scale, and $r = 50$ inches, the distance of knife-edge of pendulum above this scale, a and b the arcs in inches at the beginning and end of set.

2. Reduction to density of air under pressure of 26 inches, and temperature 32° F.

$$\text{Correction} = 0.32 \left(\frac{P}{1 \times .0023\,(t-32)} - 26\right)$$

P being the mean pressure, and t the mean temperature of the set.

3. Reduction to mean temperature of all the sets with each pendulum.

Pendulum No. 4: Correction = 0.458 $(t-t_m)$
Pendulum No. 6: Correction = 0.442 $(t-t_m)$
Pendulum No. 11: Correction = 0.450 $(t-t_m)$

t being the temperature of the set, and t_m the mean temperature of all the sets with the pendulum.

These results were afterwards reduced to 62° F. by the use of the above co-efficients.

Determination of the rate of the R. S. Clock.

Observations of the transits of stars were made as frequently as the weather would permit during pendulum observations at each station. Sidereal chronometer, Negus No. 1539, was used in recording the star observations, except at Sydney, and was compared with the other two chronometers, and the R. S. Clock at the time of star observations, and at the beginning and end of each set of pendulum observations.

At Sydney, Negus No. 1539 was first compared with the Sydney Observatory Clock, Frodsham No. 987, whose rate was determined by transits of stars observed by H. C. Russell, the director of the Sydney Observatory.

The time observations at Auckland and Singapore were made with meridian telescope No. 13, and at Tokio with the transit of the Tokio Observatory, by Professor Pritchett. At Singapore no chronograph was used. At San Francisco the first two night's observations were made by Professor Pritchett, and the remaining nights by myself. At Washington the rate of the R. S. Clock was determined from signals received from the Naval Observatory.

In reducing the time observations, the times of transit over the mean of the wires were corrected for aberration, rate, and level. The collimation constant was then computed from the stars observed, clamp west and east, and an azimuth constant was computed for each of these positions of the instrument by the method of least squares, as given in Appendix No. 14 of the Coast and Geodetic Survey Report for 1880.

The rate of the R. S. Clock has been taken as uniform between star observations. The comparisons of the other time-pieces were made as checks, but have not been used.

THERMOMETERS.

I was furnished with two Baudin thermometers that had been compared and examined by Prof. C. S. Peirce, and it was intended that frequent comparisons should be made between them and Nos. 714 and 715. At Auckland and Sydney there was no opportunity, and at Batavia they were accidentally carried off to England with my trunk, in which they had been placed for safety. They were finally obtained without injury on my return to the United States. On completion of the observations at Washington in April, 1884, all the thermometers were turned over to Prof. C. S. Peirce for comparison, and I here give his letter addressed to you concerning them:

UNITED STATES COAST AND GEODETIC SURVEY,
Baltimore, April 29, 1884.

DEAR SIR: I have determined the corrections to the thermometers of the Kater pendulum apparatus; they are as follows:

	No. 714.	No. 715.	Temp.
	°	°	°
First comparison.	— 0.05	— 0.35	68.05
Second comparison.	— 0.09	— 0.39	68.61
Third comparison.	— 0.07	— 0.37	70.43
Means.	— 0.07	— 0.37	

In these comparisons the bulbs were down. When 715 is inverted it reads 0°.2 more, and its correction is larger.

The Kew certificate dated November, 1881, gives the following corrections:

Temp.	No. 714.	No. 715.
°	°	°
32	— 0.45	— 0.50
42	— 0.40	— 0.60
52	— 0.35	— 0.65
62	— 0.30	— 0.70
72	— 0.30	— 0.60
82	— 0.30	— 0.70
92	— 0.42	— 0.70

Subsequently the following corrections were found at Kew Observatory:

[Nov. 9. Temp. 60°.]			[Nov. 11. Temp. 70°.]		
Hour.	714	715	Hour.	714	715
Noon.	— 0.25	— 0.95	11 a. m.	— 0.30	— 0.65
2 p. m.	— 0.25	— 0.70	1 p. m.	— 0.30	— 0.65
3 p. m.	— 0.25	— 0.70	2½ p. m.	— 0.30	— 0.70
4 p. m.	— 0.30	— 0.70	4 p. m.	— 0.30	— 0.70
7 p. m.	— 0.30	— 0.60			

I suppose that in these observations 715 was right side up. (It is used upside down.)

Owing to the peculiar manner of determining the fixed points at Kew, the corrections obtained there will be more negative than those I should get.

They will take a calibrated thermometer, and first keep it in ice for hours, until the glass has considerably contracted and the mercury has risen, and will then mark the freezing point. They will then raise it to the boiling point and mark the boiling point. Suppose, then, such a thermometer shows 20° C., without correction according to them. I should take the thermometer and place it in ice for about 100 seconds, and observe the freezing point. It would mark a lower point than zero, and would have a positive correction, according to me.

The discrepancy would be a little less owing to my 100° occupying a longer range on the stem but still there would be a difference at ordinary temperatures of 0°.2 or 0°.3 F. The inference is, therefore, that these thermometers have not changed since the Kew determinations, especially as the negative correction ought, with time, to increase instead of diminishing. Therefore, since the absolute temperature is not desired, but the difference from Herschel's temperatures, the Kew corrections should be adhered to in reducing Mr. Smith's work.*

Yours, very respectfully,

C. S. PEIRCE,
Assistant.

Prof. J. E. HILGARD,
Superintendent.

A correction of $-0°.50$ to the mean of the readings of Nos. 714 and 715 has been used throughout.

PROBABLE ERRORS.

No probable errors have been assigned to the results, and as no correction has been made for hourly rate, I do not see that any probable error can be assigned from the observations themselves, except from the means of days at Washington, and the differences of the results in the two positions of the pendulums at the various stations, and these are not sufficient in number.

COMPUTATIONS.

The first reduction of the observations at all the stations except Washington was made by myself, and a complete revision by Mr. H. Farquhar. The reduction of the Washington observations has been made jointly by Mr. Farquhar and myself, each step having been gone over twice.

On the following pages are given the details of the observations at each station in the order in which they were occupied. With what has already been said the headings of the various columns are sufficient explanation.

*The correctness of this inference by Mr. Peirce is shown by the following statement which I received from him December 11, 1884: "1884, July 20.—Thermometers 714 and 715 were immersed in ice water about 40° C. for five hours; being then in pounded ice for half an hour, both read 32°.4." As 715 reads 0°.2 greater when inverted, the correction to the mean of the two thermometers would be — 0°.5 E. S.

AUCKLAND, NEW ZEALAND.

To the southwest of the Transit of Venus station, in the reservation known as the Domain, was a brick building called the Block House. The building was at first rented as a store-house, and was afterwards found to be the best place we could get to swing the pendulums. In the east room was constructed a pier of scoriæ and lime seven feet square, and one and a half feet deep, upon which the apparatus was mounted. The clock was attached to the east wall of the building.

The position of this pier is: Latitude 36° 51′ 51″ S.; longitude 11^h 39^m 07^s.1 E.; height, 261 feet.

The latitude is from observations made by Professor Pritchett with Meridian Tel. No. 13; the longitude and height from geodetic connection with the New Zealand Survey.

Just before the beginning of these observations I began to suffer with a severe infliction in my eyes which soon compelled me to give up all observing, and after the first day all the observations at this station were made by Professor Pritchett.

Auckland, New Zealand.—Time observations.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
1882			h. m. s.							h. m. s.	
Nov. 27	ζ Arietis.	W.	3 07 40.08	—0.02	+0.01	0.58	+0.08	—0.01	39.56	3 08 12.62	+33.06
	ι Hydri.	W.	18 22.98	—0.09		+2.02	+0.48	—0.05	25.34	18 58.43	.09
	ε Eridani.	W.	26 53.88	—0.02		0.30	+0.12	—0.01	53.67	27 26.81	.14
	η Tauri.	W.	40 01.38	—0.02		—0.62	+0.07	—0.01	00.80	40 33.88	.08
	γ Hydri.	E.	48 33.20	—0.07		+1.26	+0.23	+0.04	34.66	49 07.78	.12
	γ Eridani.	E.	3 52 02.92	—0.02		—0.23	+0.07	+0.01	02.75	3 52 36.02	.27
	o¹ Eridani.	E.	4 05 38.14	—0.02	—0.01	—0.28	+0.07	+0.01	37.91	4 06 11.04	.13
	γ Tauri.	E.	4 12 37.52	—0.02	—0.01	—0.45	+0.05	+0.01	37.10	4 13 10.11	+33.01
Nov. 28	β Hydri.	W.	0 19 02.20	—0.09	+0.01	+1.70	0.00	—0.52	03.30	0 19 36.20	+32.90
	β Ceti.	W.	0 37 11.46	—0.02		—0.18		—0.12	11.14	0 37 44.06	.92
	δ Hydri.	W.	2 19 09.26	—0.05		+0.82		—0.31	09.72	2 19 42.64	.92
	ξ² Ceti.	W.	2 21 25.66	—0.02		—0.39		—0.11	25.14	2 21 58.04	+32.90
Nov. 29	ω Piscium.	W.	23 52 47.04	—0.02	+0.01	—0.50	—0.09	—0.18	46.26	23 53 19.21	+32.95
	33 Piscium.	W.	23 58 49.49	—0.02	+0.01	—0.37	—0.10	—0.18	48.83	23 59 21.73	+32.90
	α Andromedæ.	W.	0 01 49.78	—0.02	+0.01	—0.76	—0.06	—0.21	48.74	0 02 21.76	+33.02
	γ Pegasi.	W.	06 41.89	—0.02		—0.59	—0.08	—0.19	41.01	07 13.85	+32.84
	β Hydri.	W.	19 02.26	—0.09		+2.29	—0.43	—0.86	03.17	19 36.10	.93
	β Ceti.	E.	37 11.27	—0.02		—0.24	—0.12	+0.19	11.08	37 44.05	.97
	ζ Andromedæ.	E.	40 37.42	—0.02		—0.69	—0.06	+0.20	36.85	41 09.73	.88
	δ Piscium.	E.	42 05.57	—0.02		—0.50	—0.08	+0.18	05.15	42 38.00	.85
	ε Piscium.	E.	0 56 21.13	—0.02		—0.52	—0.08	+0.18	20.69	0 56 53.61	+32.92
	β Andromedæ.	E.	1 02 40.50	—0.02	—0.01	—0.85	—0.04	+0.22	39.80	1 03 12.81	+33.01
	κ Tucanæ.	E.	1 11 15.54	—0.05	—0.01	+1.12	—0.28	+0.51	16.83	1 11 49.76	+32.93
Nov. 30	ε Eridani.	W.	3 26 55.22	—0.02	+0.01	—0.30	—0.14	—0.20	54.57	3 27 26.82	+32.25
	γ Hydri.	W.	48 35.24	—0.07		+1.48	—0.46	—0.75	35.44	49 07.73	.29
	γ Eridani.	W.	3 52 04.32	—0.02		—0.26	—0.15	—0.21	03.68	3 52 36.03	.35
	o¹ Eridani.	E.	4 05 38.98	—0.02		—0.29	—0.13	+0.20	38.74	4 06 11.05	.31
	δ Muscæ.	E.	25 26.54	—0.10		+2.39	—0.65	+1.21	29.39	26 01.67	.28
	α Tauri.	E.	4 28 42.56	—0.02		—0.47	—0.09	+0.21	42.19	4 29 14.45	+32.26
Dec. 1	θ¹ Ceti.	W.	1 17 40.46	—0.02	0.00	—0.26	—0.07	—0.39	39.72	1 18 11.80	+32.08
	α Eridani.	W.	1 32 50.97	—0.03		+0.36	—0.13	—0.71	50.46	1 33 22.53	+32.07

Auckland, New Zealand.—Time observations—Continued.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
1882			h. m. s.							h. m. s.	
Dec. 1	ο Piscium.	W.	1 38 43.34	—0.02	0.00	—0.39	—0.05	—0.39	42.49	1 39 14.59	+32.10
	ζ Ceti.	W.	1 45 11.21	—0.02		—0.24	—0.07	—0.39	10.49	1 45 42.52	+32.03
Dec. 2	β Andromeda.	W.	1 02 42.50	—0.02	0.00	—0.88	+0.04	—0.69	40.95	1 03 12.79	+31.84
	κ Tucanæ.	W.	11 18.12	—0.05		+1.17	+0.23	—1.63	17.84	11 49.65	.81
	Ceti.	W.	17 40.96	—0.02		—0.37	+0.09	—0.58	40.08	18 11.79	.71
	η Piscium.	W.	24 44.30	—0.02		—0.62	+0.06	—0.59	43.13	25 14.94	.81
	π Piscium.	E.	30 23.16	—0.02		—0.41	+0.21	+0.58	23.52	30 55.34	.82
	α Eridani.	E.	32 48.76	—0.03		+0.35	+0.55	+1.07	50.70	33 22.50	.80
	ν Piscium.	E.	34 49.82	—0.02		—0.35	+0.23	+0.58	50.26	35 22.06	.80
	ο Piscium.	E.	1 38 42.32	—0.02		—0.38	+0.23	+0.58	42.73	1 39 14.49	+31.76
Dec. 4	β Ceti.	E.	0 37 13.10	—0.02	+0.01	—0.19	+0.04	+1.02	13.96	0 37 44.00	+30.04
	δ Piscium.	E.	0 42 07.30	—0.02	+0.01	—0.39	+0.03	+0.97	07.90	0 42 37.96	+30.06
	β Andromeda.	E.	1 02 42.26	—0.02	+0.01	—0.65	+0.02	+1.17	42.78	1 03 12.77	+29.99
	θ Ceti.	E.	1 17 40.96	—0.02	0.00	—0.27	+0.04	+0.98	41.69	1 18 11.78	+30.09
	δ Hydri.	W.	2 19 14.19	—0.05	—0.01	+0.80	+0.16	—2.71	12.38	2 19 42.45	.07
	ξ² Ceti.	W.	21 29.32	—0.02	—0.01	—0.38	+0.05	—0.98	27.98	21 58.03	.05
	δ Ceti.	W.	2 33 02.01	—0.02	—0.01	—0.32	+0.05	—0.96	00.75	2 33 30.80	+30.05
Dec. 5	β Ceti.	E.	0 37 14.70	—0.02	+0.01	—0.08	+0.03	—0.07	14.57	0 37 43.99	+29.42
	θ Ceti.	E.	1 17 42.64	—0.02		—0.11	+0.03	—0.07	42.47	1 18 11.77	.30
	η Piscium.	E.	24 45.96	—0.02		—0.19	+0.02	—0.07	45.70	25 14.92	.22
	α Eridani.	E.	32 53.12	—0.03		+0.16	+0.06	—0.13	53.18	33 22.44	.26
	ο Piscium.	W.	38 45.22	—0.02		—0.19	+0.05	+0.07	45.13	39 14.47	.34
	ζ Ceti.	W.	45 13.18	—0.02		—0.12	+0.06	+0.07	13.17	45 42.49	.32
	ξ Piscium.	W.	1 47 02.22	—0.02		—0.17	+0.05	+0.07	02.15	1 47 31.40	.25
	δ Hydri.	W.	2 19 12.40	—0.05	—0.01	+0.40	+0.16	+0.20	13.10	2 19 42.41	+29.31

[Instrumental corrections, meridian telescope No. 13.]						[Corrections and daily rates, sidereal chronometer Negus No. 1539.]		
Date.	Azimuth.		Level.		Collimation.	T_0	ΔT	Daily rate.
	West.	East.	West.	East.				
1882.								
Nov. 27	+0.65	+0.55	+0.13	+0.08	—0.01	3 43	+33.11	—.227
28	+0.54	. . .	0.00	. . .	—0.11?	0 55	+32.91?	+.010
29	+0.73	+0.73	—0.12	—0.12	—0.18	0 31	+32.92	—.550
30	+0.64	+0.57	—0.16	—0.15	—0.20	4 02	+32.29	—.244
Dec. 1	+0.54	. . .	—0.08	. . .	—0.38?	1 40	+32.07?	—.283
2	+0.76	+0.53	+0.10	+0.31	—0.57	1 25	+31.79	—.867
4	+0.53	+0.56	+0.07	+0.04	—0.96	1 35	+30.05	—.752
5	+0.27	+0.24	+0.07	+0.03	+0.07	1 31	+29.30	

Auckland, New Zealand.—Time Observations—Continued.

[Comparisons with clock.]

Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.
1882.	*h. m. s.*	*h. m. s.*	
Nov. 27	1 50 05	1 40 41	
	2 20 15	2 10 45	+284.159
	8 00 17	7 49 40	
28	1 33 10	1 19 05	
29	20 06 20	19 48 35	284.681
	2 15 00	1 56 02	283.638
30	3 00 16	2 36 25	
Dec. 1	21 19 33	20 52 05	284.105
	3 18 24	2 49 45	284.299
2	22 02 11	21 29 50	
	4 06 01	3 32 28	283.745
4	22 06 12	21 24 21	
	3 54 40	3 11 40	+283.641
5	2 37 29.06	1 50 00	

[Number of vibrations of R. S. clock pendulum in mean solar day.]

Date.	Sets.	$86636.555 - (r + \frac{r}{365})$
1883.		
Nov. 27–28	I–II	86351.62
28–29	III–VI	1.10
29–30	VII–X	2.14
Nov. 30, Dec. 1	XI–XIV	1.67
1–2	XV–XVIII	1.48
2–4	XIX–XXVI	2.03
		2.14

Auckland, New Zealand.—Pendulum No. 4.

[d=o. inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 63°.47	Corrected number of vibrations in mean solar day.	Means.	Means.
1882.				*h. m. s.*	*Inches.*		*Inches.*							
Nov. 27	I	M	1	13 25 41.60	1.00	59.95	27.21							
28			31	19 06 07.00	.15	63.50	27.43	86097.97	+ .14	— .14	— .80	86097.17	Reject.	
	II		1	19 17 54.70	1.06	64.20	27.48							
			31	1 03 25.20	.15	65.00	27.50	86101.69	+ .16	— .14	+ .52	86102.23		
	III		1	1 10 11.25	1.16	65.00	27.61							
			31	6 55 52.20	.17	63.85	27.44	1.30	+ .19	— .12	+ .44	1.81		
	IV.		1	7 11 40.30	1.11	63.85	27.44						86101.73	
			31	12 57 36.70	.17	61.75	27.34	1.49	+ .18	— .13	— .31	1.23		
28	V		1	13 16 02.30	1.15	62.15	27.37							
29			31	19 02 04.40	.17	65.00	27.49	1.56	+ .19	.14	+ .05	1.66		
	VI	P	1	19 27 04.83	1.29	65.90	27.51							86102.08
			2	19 38 34.50	. . .	. . .	. . .							
			31	1 12 21.00	.18	64.75	27.44	1.00	+ .23	— .16	+ .85	1.92		
	VII		1	1 27 12.40	1.07	64.75	27.44							
			31	7 13 28.00	.15	62.10	27.23	2.75	+ .16	— .16	— .02	2.73		
	VIII		1	7 30 30.50	1.18	62.15	27.24						86102.42	
			31	13 17 25.50	.17	60.85	27.15	3.23	+ .20	— .17	— .90	2.36		
29	IX		1	13 27 39.70	1.19	61.10	27.16							
30			31	19 14 36.80	.17	63.15	27.29	3.25	+ .21	— .17	— .62	2.67		

Auckland, New Zealand.—Pendulum No. 6.

[d=0.8 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 62°.60	Corrected number of vibrations in mean solar day.	Means.	Means.
1882.				*h. m. s.*	*Inches.*	°	*Inches.*							
Nov. 30	X	M.	1	20 31 21.90	1.20	65.25	27.32							
			43	2 16 28.60	.15	62.65	27.17	86001.03	+ .19	— .20	+ .60	86001.62	86001.53	86001.84
	XI		1	2 24 37.50	1.24	62.65	27.21							
			43	8 10 12.10	.17	60.85	27.12	1.84	+ .21	— .19	— .38	1.48		
	XII		1	8 19 01.40	1.22	60.90	27.12							
			43	14 04 48.80	.16	60.60	27.10	2.06	+ .20	— .18	— .82	1.26		
30	XIII		1	14 12 22.70	1.18	60.85	27.12							
Dec. 1			43	19 58 03.40	.15	63.45	27.25	1.95	+ .19	— .19	— .20	1.75		
	XIV	P.	1	20 42 03.20	1.14	65.00	27.48							
			43	2 27 28.60	.14	63.55	27.42	1.69	+ .17	— .14	+ .74	2.46	86002.15	
	XV		1	2 36 58.30	1.14	63.90	27.41							
			43	8 22 44.40	.13	62.25	27.32	1.85	+ .17	— .15	+ .21	2.08		
	XVI		1	8 31 19.90	1.15	62.15	27.31							
			43	14 17 22.80	.14	61.50	27.26	2.13	+ .17	— .15	— .34	1.81		
	XVII		1	14 28 18.00	1.17	61.85	27.28							
			43	20 14 16.60	.14	64.10	27.40	2.06	+ .18	— .15	+ .17	2.26		

Auckland, New Zealand.—Pendulum No. 11.

[d=0.8 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 63°.56	Corrected number of vibrations in mean solar day.	Means.	Means.
1882.				*h. m. s.*	*Inches.*	°	*Inches.*							
Dec. 2	XVIII	M.	1	21 21 36.80	1.11	66.05	27.74							
			3	21 40 48.70										
			37	3 08 35.50	.14	64.00	27.61	86052.84	+ .16	− .09	+ .66	86053.57	86053.62	86053.43
	XIX		1	3 20 22.90	0.98	64.00	27.73							
			37	9 07 58.60	.12	62.15	27.62	3.92	+ .13	− .06	− .22	3.77		
	XX		1	9 16 52.00	1.30	62.20	27.64							
			37	15 04 31.80	.15	61.70	27.61	3.98	+ .22	− .05	− .72	3.43		
2	XXI		1	15 12 02.88	1.28	61.90	27.62							
3			37	20 59 37.80	.16	63.60	27.68	3.91	+ .22	− .06	− .36	3.71		
	XXII	P.	1	21 29 38.38	1.19	64.25	27.84							
			37	3 16 10.25	.15	63.80	27.78	3.00	+ .19	− .03	+ .21	3.37	86053.24	
	XXIII		1	3 23 36.70	1.21	63.80	27.81							
			37	9 10 18.60	.13	63.40	27.77	3.15	+ .19	− .03	+ .02	3.33		
	XXIV		1	9 17 36.90	1.12	63.60	27.78							
			37	15 04 16.40	.14	63.40	27.76	3.11	+ .17	− .04	− .03	3.21		
3	XXV		1	15 11 35.50	1.11	63.50	27.78							
4			37	20 57 56.80	.13	64.15	27.78	3.85	+ .16	− .04	+ .12	3.09		
4	XXVI		1	21 06 10.70	1.08	64.25	27.80							
			37	2 52 26.75	.13	64.30	27.80	2.77	+ .15	− .04	+ .32	3.20		
			38	3 02 05.15										

SYDNEY, NEW SOUTH WALES.

It was intended to swing the pendulums at Fort Macquarie, where Freycinet and Duperry had swung pendulums in 1819–'22–'25, but it was found impracticable to do so. The magazine was the only place at the fort suitable for pendulum work, and was not large enough to admit the Kater apparatus.

Mr. H. C. Russell very kindly offered the facilities of the Sydney Observatory, of which he is the Director. The pendulums were hung in the cellar under the transit room. The floor and walls are concreted. The foundation is very solid and the temperature very constant. It would be difficult to find a more suitable place for pendulum observations—as the results show. The apparatus was set upon the floor, and the clock attached to the west wall. The position of this station as given in the volume of Sydney Observations, 1877–'78, is: Latitude, 33° 51′ 41″.1 S.; longitude, $10^h\ 04^m\ 50^s.81$ E.; height, 140 feet.

After the apparatus was set up at this station the work was conducted entirely by Professor Pritchett, my eyes being still in such a condition that I could make no observations.

Our sincere thanks are due to Mr. Russell for his many attentions and personal assistance in the pendulum work.

Time observations, with Sydney Observatory meridian circle and sidereal clock Frodsham, No. 987, as furnished by Mr. H. C. Russell.

Date.	Star.	R. A.			Corrected transit.			Δ T of observation clock.
1883.								
Jan. 5	κ Orionis.	5	42	14.53	5	41	45.11	+29.42
	μ Geminorum.	6	15	55.40	6	15	25.92	.48
	α Argus.	6	21	23.82	6	20	54.38	+29.44
Jan. 6	A Tauri.	3	57	48.81	3	57	17.95	+30.86
	ε Tauri.	4	21	49.23	4	21	18.37	.86
	μ Eridani.		39	41.10		39	10.18	.92
	ι Aurigæ.	4	49	24.99	4	48	54.14	.85
	ε Leporis.	5	00	32.45	5	00	01.47	.98
	α Aurigæ.	5	08	05.90	5	08	34.93	+30.97
Jan. 7	γ Tauri.	4	13	10.18	4	12	38.01	+32.17
	ε Tauri.		21	49.22		21	16.97	.25
	α Tauri.		29	14.58		28	42.31	.27
	μ Eridani.		39	41.10		39	08.89	.21
	ι Aurigæ.	4	49	24.99	4	48	52.87	.12
	ε Leporis.	5	00	32.44	5	00	00.13	.31
	β Orionis.		08	05.91		07	33.62	.29
	δ Orionis.	5	26	03.86	5	25	31.58	+32.28
Jan. 8	β Geminorum.	7	38	11.80	7	38	38.18	+33.67
	ξ Argus.	7	44	24.72	7	43	51.03	+33.69
Jan. 9	υ Orionis.	6	00	55.85	6	00	21.23	+34.62
	η Cancri.	8	36	33.08	8	35	58.43	.65
	ε Hydræ.	8	40	36.92	8	40	02.32	+34.60
Jan. 11	ι Aurigæ.	4	49	24.97	4	48	48.43	+36.54
	ε Leporis.	5	00	32.42	4	59	55.87	.55
	β Orionis.	5	08	56.89	5	08	20.37	+36.52

[Corrections and Rates of Sidereal Clock, Frodsham No. 987.]

Date.	T_0	$\triangle T$	Daily rate.
1883.	*h. m.*	*s.*	
Jan. 5	6 06	+ 29.45	+ 1.547
6	4 39	+ 30.91	+ 1.323
7	4 46	+ 32.24	+ 1.284
8	7 41	+ 33.68	+ 0.937
9	7 45	+ 34.62	+ 1.019
11	4 59	+ 36.54	

[Comparisons of Sid. Clock Frodsham No. 987, and Sid. Chron. Negus No. 1539.]

Date.	Negus Chronometer 1539.	Frodsham Clk. 987.	Correction to Frodsham 987.	Correction to Negus 1539.	Daily rate of Negus 1539.
1883.					*s.*
Jan. 5	5 58 04.70	5 57 59	+ 29.44	+ 23.74	— 0.196
6	5 18 06.40	5 17 59	30.95	23.55	— 0.049
7	5 59 07.80	5 58 59	32.30	23.50	— 0.335
8	7 03 09.50	7 02 59	33.65	23.15	— 0.579
9	7 55 11.08	7 54 59	34.63	22.55	— 0.512
11	5 22 13.98	5 21 59	+ 36.56	+ 21.58	

[Comparisons of Chron. 1539 with R. S. clock.]

Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.
1883.			
Jan. 5	6 07 36	11 06 00	+ 296.428
6	6 53 07	11 46 25	+ 296.109
7	5 44 00	10 42 34	+ 296.122
8	7 09 30	11 52 52	+ 295.930
9	8 00 27	12 38 42	+ 296.025
11	5 19 50	9 48 45	

[Number of vibrations of R. S. clock pendulum in mean solar day.]

Date.	Sets.	$86636.555 - (r + \frac{r}{365})$
1883.		
Jan. 5–6	I–IV	86339.32
6	V	.62
6–7	VI–VIII	.64
7	IX	.63
7–8	X–XIII	.62
8–9	XIV–XVII	.81
9–11	XVIII–XXIV	.72

Sydney, New South Wales.—Pendulum No. 4.

[d=0.85 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 68°.56	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.				h. m. s.	Inches.	°	Inches.							
Jan. 5	I	M.	1	5 51 08.40	1.06	68.75	28.05							
			32	11 45 22.90	.13	68.60	28.05	86087.47	+ .15	− .04	+ .05	86087.63	86087.61	86087.93
	II		1	12 04 19.10	1.04	68.65	28.19							
			32	17 58 34.60	.14	68.40	28.16	7.48	+ .15	.00	− .02	7.61		
5	III		1	18 09 58.30	1.05	68.55	28.17							
6			32	0 04 12.20	.14	68.40	28.15	7.46	+ .15	− .01	− .04	7.56		
	IV		1	0 13 36.50	1.11	68.80	28.17							
			2	0 25 00.10										
			31	5 56 23.10	.14	68.60	28.16	7.44	+ .16	− .01	+ .06	7.65		
	V	P.	1	6 20 31.30	1.04	68.90	28.08							
			31	12 03 47.10	.15	68.50	28.04	8.10	+ .15	+ .04	− .06	8.15	86088.25	
	VI		1	12 13 10.20	0.97	68.60	28.05							
			31	17 56 36.90	.13	68.25	28.04	8.25	+ .13	− .04	− .06	8.28		
	VII		1	18 07 58.90	1.04	68.50	28.22							
			31	23 51 17.30	.13	68.35	28.21	8.15	+ .14	+ .01	− .06	8.24		
7	VIII		1	0 00 42.75	1.17	68.55	28.22							
			31	5 43 58.70	.17	68.55	28.22	8.12	+ .19	+ .01	.00	8.32		

Sydney, New South Wales.—Pendulum No. 6.

[d = 0.85 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 69°.04	Corrected number of vibrations in mean solar day.	Means.	Mean of M and P.
1883.				h. m. s.	Inches.	°	Inches.							
Jan. 7	IX	M.	1	6 27 02.20	1.13	70.75	28.20							
			42	12 01 04.75	.15	68.85	28.10	85986.39	+ .17	− .03	+ .34	85986.87		
	X		1	12 09 32.60	1.11	68.85	28.11							
			2	12 17 41.25										
			44	18 00 15.50	.13	68.45	28.08	6.76	+ .16	− .03	− .17	6.72	85986.82	
7	XI		1	18 07 13.70	1.11	68.65	28.10							
8			44	23 58 04.00	.13	68.60	28.09	6.88	+ .16	− .03	− .19	6.82		
	XII		1	0 05 26.90	1.12	68.70	28.10							
			44	5 56 11.40	.13	69.10	28.09	6.79	+ .16	− .03	− .06	6.86		85987.21
	XIII	P.	1	6 15 56.30	1.01	69.50	28.25							
			43	11 58 55.75										
			44	12 07 06.50	.11	69.05	28.21	7.22	+ .13	.00	+ .11	7.46		
	XIV		1	12 16 26.70	1.01	69.05	28.21							
			44	18 07 44.00	.11	68.90	28.21	7.52	+ .13	.00	− .03	7.62	85987.60	
8	XV		1	18 14 37.70	1.04	69.10	28.21							
9			44	0 05 54.25	.12	69.05	28.20	7.51	+ .14	.00	+ .02	7.67		
	XVI		1	0 13 34.20	1.06	69.05	28.21							
			44	6 04 50.38	.11	69.00	28.20	7.51	+ .14	.00	− .01	7.64		

Sydney, New South Wales.—Pendulum No. 11.

[d = 0.85 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 69°.45	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.				h. m. s.	Inches.	°	Inches.							
Jan. 9	XVII	M.	1	6 54 37.40	1.08	70.35	28.19							
			38	12 48 15.80	.12	69.25	28.10	86038.70	+ .15	— .04	+ .16	86038.97		
	XVIII		1	12 56 44.80	1.16	69.45	28.10							
			37	18 41 03.40	.15	69.15	28.09	8.81	+ .18	— .04	— .07	8.88	86038.91	
9	XIX		1	18 48 53.00	1.08	69.30	28.10							
			2	18 58 25.88										
10			37	0 33 13.70	.12	69.05	28.10	8.84	+ .15	— .04	— .12	8.83		
	XX		1	0 43 25.10	1.13	69.35	28.23							
			37	6 27 43.10	.14	69.45	28.23	8.80	+ .17	.00	— .02	8.95		86038.73
	XXI	P.	1	6 42 00.90	1.13	70.00	28.23							
			37	12 25 42.80	.13	69.35	28.18	8.27	+ .17	— .01	+ .10	8.53		
	XXII		1	12 33 33.70	1.16	69.65	28.19							
			39	18 36 28.40	.13	69.25	28.18	8.37	+ .17	— .02	.00	8.52		
10	XXIII		1	18 43 25.50	1.10	69.35	28.19						86038.55	
11			38	0 36 53.90	.12	69.35	28.18	8.46	+ .15	— .02	— .04	8.55		
	XXIV		1	0 45 00.10	1.12	69.60	28.19							
			38	6 38 27.40	.13	69.30	28.17	8.45	+ .16	— .02	.00	8.59		

SINGAPORE, STRAITS SETTLEMENTS.

At Singapore the pendulums were swung in the laboratory of the New European Hospital. This is a large, massive building on a slight rise of ground to the west of the town. The laboratory on the ground floor was at this season protected from the sun, and has a solid, tiled floor. It was very well suited for pendulum work. The apparatus was set upon the floor, and the clock was attached to a beam on the north wall. The laboratory is 4,765 feet south and 3,870 feet west of the flag-staff at Fort Canning. The position of this flag-staff is given by the United States Hydrographic Office as: Lat., 1° 17′ 33″.7 N.; long., 6^h 55^m $23^s.5$ W.; from which we find the position of the laboratory to be: Lat., 1° 16′ 46″ N.; long., 6^h 55^m 21^s E. The height of floor is 45 feet.

The transit pier was built of brick near the northwest corner of the building. Permission to occupy this building was granted by his excellency Governor Weld. Dr. Simon, the resident physician, gave us quarters, and every facility of the institution, and to Captain McCallum, R. E., in charge of the office of colonial engineers, we are indebted for very important assistance.

Singapore, Straits Settlements.—Time observations.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
1883.			h. m. s.								
March 1	a^2 Geminorum.	E.	7 27 40.18	—0.02	—0.01	—1.26	+0.01	—1.06	37.84	7 27 10.62	—27.22
	α Canis Minoris.	E.	33 41.18	—0.02	—0.01	—0.15	+0.01	—0.91	40.10	33 12.86	.24
	β Geminorum.	E.	38 41.48	—0.02		—1.06	+0.01	—1.02	39.39	38 11.82	.57
	ξ Argus.	E.	44 52.03	—0.02		+0.99	+0.01	—0.98	52.03	44 24.61	.42
	6 Cancri.	W.	7 56 50.18	—0.02		—1.28	+0.02	+1.02	49.92	7 56 22.37	.55
	15 Argus.	W.	8 03 01.20	—0.02		+1.16	+0.02	+0.98	03.34	8 02 35.94	.40
	β Cancri.	W.	10 39.37	—0.02	+0.01	—0.36	+0.02	+0.92	39.94	10 12.54	.40
	η Cancri.	W.	8 26 26.12	—0.02	+0.01	—0.90	+0.02	+0.96	26.19	25 59.00	—27.19
March 2	α Columbæ.	W.	5 35 51.64	—0.02	—0.01	—0.19	+0.10	+1.21	52.73	5 35 26.05	—26.68
	κ Orionis.	W.	42 39.86	—0.02	—0.01	—0.05	+0.10	+1.02	40.92	42 13.95	.97
	α Orionis.	W.	5 59 17.50	—0.02		+0.03	+0.10	+1.01	18.62	5 48 52.01	.61
	ν Orionis.	W.	6 01 21.02	—0.02		+0.06	+0.10	+1.04	22.20	6 00 55.41	.79
	η Geminorum.	W.	08 16.38	—0.02		+0.11	+0.10	+1.08	17.65	07 50.92	.73
	μ Geminorum.	E.	16 22.76	—0.02		+0.10	+0.08	—1.08	21.84	15 55.05	.79
	α Argus.	E.	21 51.36	—0.03		—0.33	+0.07	—1.64	49.43	21 22.70	.73
	γ Geminorum.	E.	31 26.90	—0.02	+0.01	+0.07	+0.08	—1.04	26.00	30 59.19	.81
	ξ Geminorum.	E.	6 39 13.02	—0.02	+0.01	+0.05	+0.08	—1.03	12.11	38 45.42	—26.69
March 3	μ Geminorum.	W.	6 16 22.66	—0.02	—0.01	—1.83	+0.17	+0.27	21.24	6 15 55.04	—26.20
	α Argus.	W.	21 41.98	—0.03		+6.19	+0.17	+0.41	48.72	21 22.66	.06
	γ Geminorum.	W.	31 26.22	—0.02		—1.32	+0.17	+0.26	25.31	30 59.18	26.13
	ξ Geminorum.	W.	39 11.80	—0.02		—1.03	+0.17	+0.26	11.18	38 45.41	25.77
	θ Canis Majoris.	E.	49 12.26	—0.02		+1.06	+0.14	—0.26	13.18	48 47.10	26.08
	ε Canis Majoris.	E.	54 27.06	—0.02		+2.61	+0.14	—0.28	29.51	54 03.49	.02
	γ Canis Majoris.	E.	6 58 54.68	—0.02		+1.37	+0.14	—0.26	55.91	6 58 29.86	.05
	δ Geminorum.	E.	7 13 38.42	—0.02	+0.01	—1.79	+0.14	—0.27	36.49	7 13 10.46	—26.03
March 5	α Orionis.	W.	5 49 16.92	—0.02	—0.01	+0.04	+0.01	+0.56	17.50	5 48 51.96	—25.54
	ν Orionis.	W.	6 01 20.26	—0.02	—0.01	+0.08	+0.01	+0.57	20.89	6 00 55.36	.53
	η Geminorum.	W.	08 15.60	—0.02		+0.13	+0.01	+0.59	16.31	07 50.87	.44
	μ Geminorum.	W.	16 19.96	—0.02		+0.13	+0.01	+0.59	20.61	15 55.00	.67
	α Argus.	W.	21 47.62	—0.03		—0.43	+0.01	+0.90	48.07	21 22.53	.54
	γ Geminorum.	E.	31 25.30	—0.02		+0.07	0.00	—0.57	24.78	30 59.14	.64
	ξ Geminorum.	E.	39 11.38	—0.02		+0.06	0.00	—0.57	10.85	38 45.37	.48
	ε Canis Majoris.	E.	54 29.84	—0.02	+0.01	—0.14	0.00	—0.63	29.06	54 03.45	.61
	γ Canis Majoris.	E.	6 58 55.94	—0.02	+0.01	—0.08	0.00	—0.57	55.28	6 58 29.82	—25.46
March 6	μ Geminorum.	W.	6 16 19.82	—0.02	—0.01	+0.18	0.00	+0.48	20.45	6 15 54.98	—25.47
	α Argus.	W.	21 47.88	—0.03		—0.60	0.00	+0.72	47.97	21 22.55	.42
	γ Geminorum.	W.	31 24.02	—0.02		+0.13	0.00	+0.46	24.59	30 59.12	.47
	ξ Geminorum.	W.	39 10.22	—0.02		+0.10	0.00	+0.45	10.75	38 45.35	.40
	θ Canis Majoris.	E.	49 13.16	—0.02		—0.05	—0.02	—0.45	12.62	48 47.04	.58
	ε Canis Majoris.	E.	54 29.54	—0.02		—0.12	—0.02	—0.50	28.88	54 03.43	.45
	γ Canis Majoris.	E.	6 58 55.70	—0.02		—0.06	—0.02	—0.46	55.14	6 58 29.80	.34
	δ Geminorum.	E.	7 13 36.20	—0.02	+0.01	+0.08	—0.02	—0.48	35.77	7 13 10.41	—25.36
March 7	a^2 Geminorum.	W.	7 27 34.28	—0.02	—0.01	+0.31	+0.05	+0.64	35.25	7 27 10.52	—24.73
	β Geminorum.	W.	38 35.76	—0.02		+0.26	+0.04	+0.61	36.65	38 11.74	.91
	ξ Argus.	W.	44 48.88	—0.02		—0.24	+0.04	+0.59	49.25	44 24.52	—24.73

Singapore, Straits Settlements.—Time observations—Continued.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	α	ΔT
1883			h. m. s.								
March 7	6 Cancri.	E.	7 56 48.14	−0.02		−0.41	+0.02	−0.61	47.12	7 56 22.29	−24.83
	β Cancri.	E.	8 10 37.92	−0.02		−0.11	+0.02	−0.55	37.26	8 10 12.47	.79
	η Cancri.	E.	8 26 24.52	−0.02	+0.01	−0.29	+0.02	−0.58	23.66	25 58.94	−24.72
March 8	η Geminorum.	W.	6 08 14.82	−0.02	−0.01	+0.10	−0.02	+0.54	15.41	6 07 50.81	−24.60
	μ Geminorum.	W.	16 18.84	−0.02	−0.01	+0.10	−0.02	+0.54	19.43	15 54.94	.49
	α Argus.	W.	21 46.52	−0.03		−0.33	−0.01	+0.82	46.97	21 22.48	.49
	γ Geminorum.	W.	31 22.90	−0.02		+0.07	−0.02	+0.52	23.45	30 59.09	.36
	ξ Geminorum.	E.	39 10.20	−0.02		+0.03	0.00	−0.52	09.69	38 45.32	.37
	θ Canis Majoris.	E.	49 12.12	−0.02		−0.03	0.00	−0.51	11.56	48 47.01	.55
	ε Canis Minoris.	E.	54 28.58	−0.02		−0.07	0.00	−0.57	27.92	54 03.39	.53
	γ Canis Majoris.	E.	6 58 54.74	−0.02		−0.04	0.00	−0.57	54.11	6 58 29.77	.34
	δ Geminorum.	E.	7 13 35.44	−0.02	+0.01	+0.05	0.00	−0.54	34.94	7 13 10.37	−24.57

[Instrumental corrections. Meridian telescope No. 13.]						[Corrections and daily rates of sid. chron. Negus 1539.]		
Date.	Azimuth.		Level.		Coll.	T_0	ΔT	Daily rate.
	West.	East.	West.	East.				
1883.	s.					h. m.		
Mar. 1	+2.51	+2.07	+0.02	+0.01	+0.90	7 52	−27.37	
								+0.667
2	−0.27	0.25	+0.10	+0.08	+1.00	6 08	−26.75	
								+0.694
3	+4.69	+4.58	+0.17	+0.14	+0.25	6 43	−26.04	
								+0.252
5	−0.33	−0.25	+0.01	0.00	+0.55	6 24	−25.54	
								+0.098
6	−0.45	−0.20	0.00	−0.02	+0.44	6 43	−25.44	
								+0.629
7	−0.50	+0.81	+0.04	+0.02	+0.54	7 54	−24.78	
								+0.317
8	−0.25	−0.12	−0.01	0.00	+0.50	6 41	−24.48	

Singapore, Straits Settlements.—Time observations—Continued.

[Comparisons of chron. and R. S. clock.]

Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.
1883.			
Mar. 1	8 44 33	9 54 20	
2	6 52 00	7 55 46	+403.073
3	7 26 19	8 23 13	403.105
5	7 08 25	7 51 59	402.753
6	7 24 53	8 01 40	402.497
7	8 35 20	9 05 05	402.946
8	7 19 32	7 42 56	+402.486

[Number of vibrations of clock pendulum in mean solar day.]

Date.	Sets.	$86636.555 -(r+\frac{r}{395})$
1883.		
Mar. 2	I	86232.35
2–3	II–IV	.34
3	V	.55
3–5	VI–XII	.69
5	XIII	.85
5–6	XIV–XVI	.95
6	XVII	.67
6–7	XVIII–XX	.50
7	XXI	.69
7–8	XXII–XXIV	.96

Singapore.—Pendulum No. 4.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 81°.77	Corrected number of vibrations in mean solar day.	Means.	Mean of M and P.
1883.				h. m. s.	*Inches.*	°	*Inches.*							
March 2	I	M.	1	5 39 38.83	1.10	83.00	28.97							
			28	11 31 38.80	.15	81.55	28.90	86011.87	+ .17	— .02	+ .23	86012.25		
	II		1	11 40 55.83	.94	81.60	28.91							
			28	17 32 41.80	.12	80.75	28.83	1.71	+ .12	— .02	— .27	1.54		
	III		1	17 42 40.25	1.17	80.80	28.84							
			28	23 34 27.60	.16	82.45	28.94	1.73	+ .19	— .02	— .07	1.83	86011.90	
2	IV		1	23 43 46.33	1.00	82.50	28.96							
			2	23 57 16.00										
3			28	5 35 15.40	.13	82.50	28.96	1.54	+ .14	— .02	+ .33	1.99		
	V	P.	1	5 52 24.50	1.01	82.60	28.97							86012.08
			29	11 57 24.00	.13	81.55	28.88	2.04	+ .14	— .02	+ .14	2.30		
	VI		1	12 10 37.30	1.01	81.55	28.88							
			27	17 49 39.60	.15	80.55	28.72	2.26	+ .15	— .04	— .33	2.04		
3	VII		1	17 59 16.70	1.03	80.55	28.72						86012.27	
			28	23 51 30.70	.15	82.00	28.91	2.35	+ .15	— .04	— .22	2.24		
4	VIII		1	23 59 45.90	1.06	82.15	28.92							
			26	5 25 36.10	.17	82.25	28.92	2.15	+ .17	— .03	+ .20	2.49		

Singapore.—Pendulum No. 6.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 81°.61	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.				h. m. s.	Inches.	°	Inches.							
Mar. 4	IX	M.	1	5 54 46.83	.98	82.55	28.98							
			39	11 34 15.25	.12	81.55	28.90	85910.93	+ .13	— .02	+ .19	85911.23	85911.18	85911.30
	X		1	11 41 02.90	1.04	81.55	28.90							
			40	17 29 30.75	.13	80.75	28.85	0.99	+ .15	— .02	— .20	0.92		
	XI		1	17 34 54.70	1.10	80.80	28.84							
			41	23 32 20.90	.12	82.10	28.94	1.02	+ .16	— .02	— .07	1.09		
4	XII		1	23 38 16.70	1.11	82.30	28.85							
			2	23 47 11.50										
5			40	5 26 44.90	.13	82.50	28.96	0.99	+ .16	— .03	+ .35	1.47		
	XIII	P.	1	5 38 27.00	1.09	82.35	28.96							
			40	11 27 21.00	.13	81.35	28.90	1.55	+ .16	— .02	+ .11	1.80	85911.41	
	XIV		1	11 32 08.50	1.08	81.45	28.90							
			41	17 29 29.10	.13	80.05	28.80	1.19	+ .15	— .02	— .38	0.94		
	XV		1	17 35 31.30	1.10	80.05	28.80							
			40	23 24 05.10	.13	82.00	28.92	1.34	+ .16	— .02	— .26	1.22		
5	XVI		1	23 29 31.70	1.06	82.00	28.94							
6			41	5 26 58.50	.13	82.45	28.96	1.29	+ .15	— .02	+ .27	1.69		

Singapore.—Pendulum No. 11.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 82°.15	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.				h. m. s.	Inches.	°	Inches.							
March 6	XVII	M.	1	5 56 36.10	1.16	82.55	29.04							
			32	11 26 23.50	.16	81.65	28.99	85962.48	+ .19	+ .01	— .02	85962.66	85962.54	85962.27
	XVIII		1	11 34 49.10	1.11	81.65	28.99							
			34	17 26 03.50	.13	81.00	28.95	2.44	+ .16	+ .01	— .37	2.24		
	XIX		1	17 31 56.75	1.14	81.00	28.95							
			34	23 23 14.90	.14	82.50	29.04	2.49	+ .17	+ .01	— .18	2.49		
6	XX		1	23 29 08.00	1.16	82.50	29.04							
			2	23 39 45.50										
7			34	5 20 12.00	.14	83.00	29.06	2.31	+ .18	.00	+ .27	2.76		
	XXI	P.	1	5 54 34.75	1.12	83.00	29.06							
			32	11 23 09.67	.16	82.05	28.99	1.50	+ .18	.00	+ .17	1.85	85962.00	
	XXII		1	11 32 24.30	1.14	82.05	28.99							
			34	17 22 16.70	.14	81.30	28.93	1.84	+ .17	.00	— .21	1.80		
	XXIII		1	17 28 58.30	1.17	81.30	28.93							
			34	23 18 55.80	.14	82.80	29.03	1.91	+ .18	— .01	— .05	2.03		
7	XXIV		1	23 31 06.50	1.08	83.00	29.02							
8			34	5 20 55.60	.13	83.00	29.00	1.80	+ .15	— .01	+ .38	2.32		

TOKIO, JAPAN.

On arrival at Tokio an invitation was received from Mr. Koto, the president of the Imperial University of Tokio, to swing the pendulums at the university where Professor Mendenhall had made such observations in 1880. The Kater apparatus could not be set up in the physical laboratory where Mendenhall had made his observations, and so a new "go-down" (mud fire-proof building) was placed at our disposal. The ground at the university is low and wet, and does not afford a good foundation, but after several days were spent in examining various localities, it was concluded that the university would be the best point.

By Mr. Koto's direction a portion of the floor of the "go-down" was taken up, and piles driven very closely together, upon which was built a solid stone pier, 7 feet square and 5 feet deep. Upon this pier the apparatus was mounted. The clock was attached to the wall.

The Tokio Observatory is nearly 2 miles distant from the university, but is connected with it by telegraph. By the kindness of H. M. Paul, professor of astronomy, the time observations were made at the observatory, and recorded on the chronograph at the university. The position of the observatory transit, as furnished by Professor Paul, is, latitude 35° 42′ 40″ N., longitude 9^h 19^m 04^s E.

The position of the pendulum pier is not so well known, but is given as latitude 35° 42′ N., longitude 9^h 19^m $0.^s$ E.; height, 20 feet.

On April 23 the apparatus was set up and ready to begin observations. About 10 p. m. quite a severe earthquake took place, which fortunately did no harm. The seismographs gave no indication of any other earthquakes till May 2, the day after the observations were completed.

Mr. Koto assigned to our aid three of the assistants of the university, who had taken part in Professor Mendenhall's observations, Messrs. Tmoka, Yamada, and Ono. One or other of these gentlemen was always present acting as interpreter, recorder, &c. We were also given quarters and servants in the main building, during our stay in Tokio, by the authorities of the university, and to them we are much indebted for attention and assistance, without which our work would have been difficult.

Tokio, Japan.—Time observations.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
1883.			h. m. s.								m. s.
Apr. 24	θ Virginis.	E.	13 08 48.86	−0.02	−0.01	+0.39	−0.07	+0.07	49.22	13 03 56.42	−4 52.80
	20 Canum Venaticorum.	E.	17 13.30	−0.02		−0.08	−0.12	+0.09	13.17	12 20.37	.80
	ζ Ursæ Majoris.	E.	24 08.82	−0.03		−0.36	−0.15	+0.12	8.40	19 15.59	.81
	ζ Virginis.	W.	33 39.22	−0.02		+0.51	−0.06	−0.07	39.58	28 46.76	.82
	η Ursæ Majoris.	W.	47 51.94	−0.02		−0.33	−0.12	−0.11	51.36	42 58.54	.82
	η Bootis.	W.	13 54 02.20	−0.02	+0.01	+0.27	−0.08	−0.07	2.31	13 49 09.55	−4 52.76
Apr. 26	χ Ursæ Majoris.	W.	11 07 59.08	−0.02	−0.01	−0.20	−0.03	−0.10	58.72	11 03 07.39	−4 51.33
	δ Leonis.	W.	12 46.88	−0.02	−0.01	+0.23	−0.02	−0.07	46.99	07 55.49	.50
	σ Leonis,	W.	19 59.94	−0.02		+0.43	−0.02	−0.07	60.26	15 08.62	.64
	λ Draconis.	W.	29 23.12	−0.05		−1.44	−0.05	−0.20	21.38	24 29.87	.51
	ν Leonis.	E.	35 51.08	−0.02		+0.28	+0.01	+0.07	51.42	31 00.02	.40
	3 Draconis.	E.	40 51.38	−0.04		−0.64	+0.03	+0.18	50.91	35 59.43	.48
	β Leonis.	E.	47 59.28	−0.02	+0.01	+0.17	+0.01	+0.07	59.52	43 07.96	.56
	β Virginis.	E.	11 49 29.78	−0.02	+0.01	+0.26	+0.01	+0.07	30.11	11 44 38.60	−4 51.51
Apr. 27	α Ursæ Majoris.	W.	11 01 24.32	−0.04	−0.01	−0.48	−0.19	−0.19	23.41	10 56 32.63	−4 50.78
	χ Leonis.	W.	03 51.98	−0.02	−0.01	+0.24	−0.09	−0.09	52.01	59 01.21	.80
	δ Leonis.	W.	12 46.36	−0.02		+0.13	−0.10	−0.10	46.27	11 07 55.48	.79
	λ Draconis.	E.	29 21.62	−0.05		−0.97	−0.20	+0.26	20.66	24 29.83	.83
	χ Ursæ Majoris.	E.	44 45.62	−0.02	+0.01	0.20	−0.12	+0.14	45.43	39 54.73	.70
	β Leonis.	E.	11 47 58.58	−0.02	+0.01	+0.21	−0.07	+0.09	58.80	11 43 07.96	−4 50.84

Tokio, Japan.—Time observations—Continued.

Date.	Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	a	ΔT
1883.			*h. m. s.*								*m. s.*
May 1	ν Ursæ Majoris.	W.	11 17 01.02	−0.02	−0.03	+0.03	+0.12	−0.05	1.07	11 12 11.90	−4 49.17
	ι Leonis.	W.	22 40.88	−0.02	−0.03	+0.27	+0.09	−0.04	41.15	17 51.83	.32
	λ Draconis.	W.	11 29 19.96	−0.05	−0.03	−1.07	+0.24	−0.12	18.93	11 24 29.66	.27
	τ Bootis.	E.	13 46 33.88	−0.02	+0.02	+0.15	+0.03	+0.04	34.10	13 41 44.86	.24
	η Bootis.	E.	13 53 58.62	−0.02	+0.02	+0.14	+0.03	+0.04	58.83	13 49 09.56	.27
	α Draconis.	E.	14 06 06.02	−0.04	+0.02	−0.53	+0.07	+0.09	5.63	14 01 16.39	.24
	α Bootis.	E.	14 15 11.26	−0.02	+0.03	+0.13	+0.03	+0.04	11.47	14 10 22.22	−4 49.25

[Instrumental corrections, Tokio transit.]						[Corrections and daily rate sidereal chron., Negus No. 1539.]		
Date.	Azimuth.		Level.		Coll.	T_0	ΔT	Daily rate.
	West.	East.	West.	East.				
1883.	*s.*	*s.*	*s.*	*s.*	*s.*	*h. m.*		
April 24	+0.88	+0.60	−0.08	−0.09	−0.07	13 26	−4 52.80	+0.684
26	+0.88	+0.47	−0.02	+0.01	−0.07	11 25	51.49	+0.702
27	+0.49	+0.59	−0.10	−0.08	−0.09	11 21	50.79	+0.379
May 1	+0.65	+0.45	+0.10	+0.03	−0.04	12 46	−4 49.25	

[Comparisons with clock.]

Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.
1883.			
April 24	13 42 47	11 23 45	+ 314.982
26	11 27 11	8 58 10	+ 315.233
27	11 24 45	8 50 30	
May 1	11 46 00	8 50 40	+ 315.428
1	14 09 06	11 13 15	

[Number of vibrations of R. S. clock in mean solar day.]

Date.	Set.	$86636.554 - \left(r - \frac{r}{365}\right)$
1883.		
April 24–25	I–VII	86320.71
26	VIII	.59
26–27	IX–XI	.46
27	XII	.36
Apr. 27–May 1	XIV–XXVIII	.26

Tokio, Japan.—Pendulum No. 4.

[$d=0.75$ inch.]

Date.		Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 57°.82	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.					h. m. s.	*Inches.*	°	*Inches.*							
April	24	I	M.	1	11 51 03.00	1.00	60.25	30.16							
				28	17 44 07.80	.09	59.60	30.32	86100.68	+ .12	+ .77	+ .96	86102.53		
		II		1	18 01 47.50	0.92	59.60	30.32							
				27	23 41 13.00	.10	58.45	30.36	100.30	+ .11	+ .82	+ .55	1.78		
	24	III		1	23 50 10.00	1.23	58.10	30.36						86101.58	
				2	0 03 21.75										
	25			28	5 41 54.40	.12	57.50	30.29	099.84	+ .19	+ .84	— .01	0.86		
		IV		1	5 50 48.25	1.05	57.40	30.29							
				29	11 56 29.00	.11	57.35	30.29	100.39	+ .14	+ .84	— .20	1.17		86101.74
		V	P.	1	12 09 47.90	1.00	57.50	30.28							
				29	18 17 35.25	.10	57.00	30.20	101.66	+ .12	+ .83	— .26	1.35		
		VI		1	18 26 54.50	0.97	57.00	30.18							
				25	23 42 01.80	.12	56.70	30.06	101.57	+ .13	+ .80	— .44	2.00		
	25	VII		1	23 55 41.70	1.02	56.60	30.05						86101.90	
	26			27	5 37 16.90	.11	57.00	29.91	101.70	+ .13	+ .76	— .47	2.12		
		VIII		1	5 46 02.90	1.02	57.00	29.92							
				28	11 40 24.00	.11	58.00	29.98	101.35	+ .13	+ .73	— .15	2.06		

Tokio, Japan.—Pendulum No. 6.

[d=0.75 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 58°.41	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.					*Inches.*	°	*Inches.*							
April 26	IX	M.	1	12 06 31.10	1.08	59.25	30.00							
			39	17 42 52.80	.12	58.00	30.12	85995.40	+ .15	+ .75	+ .09	85996.39		
	X		1	17 48 36.30	1.10	58.20	30.12							
			41	23 43 18.30	.12	56.90	30.25	5.98	+ .15	+ .80	− .38	6.55		
26	XI		1	23 49 33.88	1.15	56.90	30.25						85996.61	
			2	23 58 25.83										
27			40	5 35 30.80	.12	58.20	30.29	6.09	+ .17	+ .83	− .38	6.71		
	XII		1	5 40 54.50	1.10	58.35	30.30							
			41	11 35 31.20	.11	58.45	30.36	5.80	+ .15	+ .83	.00	6.78		
	XIII	P.	1	11 45 03.90	1.05	58.45	30.35							85996.76
			41	17 39 54.50	.12	58.50	30.28	5.91	+ .14	+ .83	+ .03	6.91		
	XIV		1	17 45 55.30	1.08	58.45	30.27							
			41	23 40 45.00	.11	58.50	30.15	5.90	+ .15	+ .79	+ .03	6.87		
27	XV		1	23 47 04.90	1.10	58.50	30.13						85996.91	
			2	23 55 57.50										
28			41	5 41 48.20	.12	59.00	29.95	5.80	+ .15	+ .74	+ .15	6.84		
	XVI		1	5 55 06.50	1.07	59.00	29.94							
			40	11 40 54.80	.12	59.90	29.75	5.75	+ .15	+ .67	+ .46	7.03		

Tokio, Japan.—Pendulum No. 11.

[d = 0.75 inch.]

Date.		Number of set.	Face.	Number of coincidence.	Time of coincidence by clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature 60°.09	Corrected number of vibrations in mean solar day.	Means.	Means.
1883.					*h. m. s.*	*Inches.*	°	*Inches.*							
April	28	XVII	M.	1	12 22 31.10	0.92	60.90	29.70							
				34	18 10 08.20	.11	60.80	29.73	86047.11	+ .11	+ .60	+ .34	86048.16		
		XVIII		1	18 17 27.10	1.04	60.80	29.73							
				32	23 44 02.20	.14	61.00	29.87	7.14	+ .15	+ .62	+ .36	8.27		
	28	XIX		1	23 51 09.60	1.09	61.00	29.86							
	29			34	5 38 38.40	.13	61.70	29.80	7.00	+ .16	+ .62	+ .57	8.35	86048.19	
		XX		1	5 46 18.70	0.96	61.95	29.82							
				34	11 33 36.40	.12	62.20	29.89	6.86	+ .12	+ .61	+ .90	8.49		
	30	XXVII		1	23 36 24.88	1.18	57.05	29.91							
May	1			34	5 25 30.90	.14	56.90	29.99	8.27	+ .19	+ .74	−1.40	7.80		
May	1	XXVIII		1	5 31 53.00	1.17	57.00	30.01							
				34	11 21 11.00	.14	57.50	30.16	8.42	+ .18	+ .78	−1.28	8.10		
April	29	XXI	P.	1	11 43 52.50	1.10	62.55	29.90							86047.77
				35	17 40 31.00	.12	62.20	29.94	5.95	+ .16	+ .63	+1.03	7.77		
		XXII		1	17 46 50.00	1.11	62.25	29.95							
				34	23 33 02.33	.13	61.25	29.96	5.99	+ .16	+ .65	+ .75	7.55		
	29	XXIII		1	23 39 10.00	1.14	61.45	29.96							
	30			34	5 25 51.60	.13	60.55	29.87	6.38	+ .17	+ .66	+ .41	7.62		
		XXIV		1	5 31 51.75	1.14	60.55	29.87						86047.35	
				2	5 42 19.50										
				34	11 18 38.60	.14	59.55	29.82	6.45	+ .17	+ .65	− .02	7.25		
		XXV		1	11 24 25.25	1.13	59.50	29.81							
				34	17 32 44.75	.13	58.15	29.84	6.84	+ .17	+ .67	− .57	7.11		
		XXVI		1	17 38 02.50	1.14	58.15	29.85							
				34	23 25 32.80	.13	57.10	29.92	7.02	+ .17	+ .71	−1.11	6.79		

SAN FRANCISCO, CAL.

At San Francisco the pendulum station was selected by Prof. George Davidson, Assistant Coast and Geodetic Survey. This station is located in the middle of Octavia street (not yet an open street), just north of Clay street. A space is inclosed by a high board fence, within which were three wooden buildings, none of which could be used for pendulum observations. Another wooden building, 10 by 20 feet, and divided into two rooms, was therefore erected. The north room was lined with heavy wrapping paper. In this room the pendulum apparatus was mounted upon a brick pier. During the pendulum observations the whole building was covered with canvas. This was the best that could be done under the circumstances, and it proved very unsatisfactory, the fluctuations of temperature being too great. Soon after the observations were begun Professor Pritchett was detached from the party, and I was assisted by E. F. Dickins, Assistant Coast and Geodetic Survey, who volunteered his services.

The geographical position of the station is latitude 37° 47′ 22″ N., longitude $8^h\ 09^m\ 42^s.7$ W.; height, 375 feet.

San Francisco, Cal.—Time observations.

Date.		Star.	Clamp.	T	κ	r	Aa	Bb	Cc	t	α	T
1883.				h. m. s.								
June 20	ζ	Virginis.	E.	13 29 35.50	−0.02	−0.01	0.00	−0.17	+0.16	35.46	13 28 46.54	−48.92
	m	Virginis.	E.	36 20.00	−0.02	−0.01	−0.01	−0.15	+0.16	19.97	35 31.12	.85
	η	Bootis.	E.	49 58.30	−0.02	−0.01	0.00	−0.21	+0.17	58.23	49 09.33	.90
	α	Draconis.	E.	14 02 04.16	−0.03		+0.01	−0.48	+0.41	04.07	14 01 15.18	.89
	ι	Virginis.	W.	10 44.80	−0.02		−0.02	−0.08	−0.16	44.52	09 55.71	.81
	109	Virginis.	W.	41 12.22	−0.02		−0.01	−0.09	−0.16	11.94	40 22.99	.95
	β	Ursæ Minoris.	W.	51 55.24	−0.07	+0.02	+0.05	−0.32	−0.60	54.32	51 05.44	.88
	ψ	Bootis.	W.	15 00 17.82	−0.02	+0.02	0.00	−0.12	−0.18	17.52	14 59 28.61	−48.91
June 21	ζ	Virginis.	W.	13 29 35.16	−0.02	−0.02	+0.02	−0.06	−0.11	34.97	13 28 46.53	−48.44
	η	Ursæ Majoris.	W.	43 46.52	−0.02	−0.01	−0.01	−0.12	−0.17	46.19	42 57.81	.38
	τ	Virginis.	W.	56 32.82	−0.02		+0.01	−0.06	−0.11	32.65	55 44.28	.36
	α	Draconis.	W.	14 02 04.06	−0.03		−0.03	−0.17	−0.28	03.55	14 01 15.14	.41
	λ	Bootis.	E.	12 46.82	−0.02		−0.01	−0.14	+0.16	46.81	11 58.31	.50
	5	Ursæ Minoris.	E.	28 37.22	−0.08	+0.01	−0.15	−0.32	+0.46	37.14	27 48.75	.39
	μ	Virginis.	E.	37 45.00	−0.02	+0.01	+0.04	−0.07	+0.11	45.07	36 56.76	.31
	109	Virginis.	E.	41 11.38	−0.02	+0.01	+0.03	−0.08	+0.11	11.43	40 22.98	−48.45
June 22	ζ	Ursæ Minoris.	E.	14 28 26.64	−0.08	−0.01	+8.85	+0.11	+0.67	38.18	14 27 48.67	−47.51
	ε	Bootis.	E.	40 43.32	−0.02	−0.01	−0.68	+0.04	+0.18	42.83	39 55.27	.56
		P. XIV. 221.	E.	51 33.38	−0.02		−1.39	+0.03	+0.17	32.17	50 44.72	.45
	δ	Bootis.	W.	15 11 37.69	−0.02		−0.31	+0.24	−0.19	37.41	15 10 49.81	.60
	γ^2	Ursæ Minoris.	W.	21 37.97	−0.06	+0.01	+7.21	+0.53	−0.52	45.14	20 57.60	.54
	α	Coronæ Borealis.	W.	30 35.11	−0.02	+0.01	−0.82	+0.22	−0.18	34.32	29 46.88	−47.44
June 23	d	Bootis.	W.	14 05 53.52	−0.02	−0.01	−0.74	+0.33	−0.04	53.04	14 05 06.23	−46.81
	4	Ursæ Minoris.	W.	09 56.49	−0.09		+9.97	+1.12	−0.19	67.30	09 20.32	46.98
	λ	Bootis.	W.	12 44.37	−0.02		+0.71	+0.44	−0.06	45.44	11 58.27	47.17
	5	Ursæ Minoris.	E.	28 25.86	−0.08		+8.42	+1.19	+0.17	35.56	27 48.61	46.95
	33	Bootis.	E.	35 17.34	−0.02	+0.01	+0.57	+0.51	+0.06	18.47	34 31.27	47.20
	ε	Bootis.	E.	40 42.27	−0.02	+0.01	−0.65	+0.40	+0.04	42.05	39 55.26	−46.79
June 24	d	Bootis.	W.	14 05 53.44	−0.02	−0.01	−0.87	+0.07	−0.37	52.24	14 05 06.22	−46.02
	4	Ursæ Minoris.	W.	09 56.20	−0.09		+11.72	+0.25	−1.60	66.48	09 20.23	.25
	λ	Bootis.	W.	12 44.44	−0.02		+0.84	+0.10	−0.48	44.88	11 58.25	.63
	5	Ursæ Minoris.	E.	28 22.94	−0.08		+10.07	+0.48	+1.39	34.80	27 48.52	.28
	33	Bootis.	E.	35 16.37	−0.02	+0.01	+0.68	+0.20	+0.47	17.71	34 31.24	.47
	ε	Bootis.	E.	40 41.67	−0.02	+0.01	−0.77	+0.16	+0.37	41.42	39 55.24	−46.18
June 25	d	Bootis.	W.	14 05 53.25	−0.02	−0.01	−0.99	+0.12	−0.47	51.88	14 05 06.20	−45.68
	4	Ursæ Minoris.	W.	09 54.29	−0.09		+13.32	+0.43	−2.04	65.91	09 20.13	.78
	λ	Bootis.	W.	12 43.63	−0.02		+0.95	+0.17	−0.61	44.12	11 58.23	.89
	5	Ursæ Minoris.	E.	28 22.12	−0.08		+9.94	+0.47	+1.76	34.21	27 48.44	45.77
	33	Bootis.	E.	35 15.83	−0.02	+0.01	+0.67	+0.20	+0.59	17.28	34 31.23	46.05
	ε	Bootis.	E.	40 40.92	−0.02	+0.01	−0.76	+0.16	+0.47	40.78	39 55.23	−45.55
June 26	d	Bootis.	W.	14 05 52.59	−0.02	−0.01	−0.89	+0.06	−0.33	51.40	14 05 06.19	−45.21
	4	Ursæ Minoris.	W.	09 54.75	−0.09		+11.97	+0.20	−1.46	65.37	09 20.07	.30
	λ	Bootis.	W.	12 43.13	−0.02		+0.86	+0.08	−0.44	43.61	11 58.21	.40
	5	Ursæ Minoris.	E.	28 22.60	−0.08		+9.57	+0.28	+1.26	33.63	27 48.39	.24
	33	Bootis.	E.	35 15.59	−0.02	+0.01	+0.64	+0.12	+0.42	16.76	34 31.22	.54
	ε	Bootis.	E.	40 40.58	−0.02	+0.01	−0.73	+0.10	+0.34	40.28	39 55.23	−45.05

Date.	[Constants of Transit.] Azimuth a. W.	E.	Level b. W.	E.	Coll. c.	[Corrections and rates of sid. chron. Negus No. 1539.] T_0	$\triangle T$	Daily rate.
1883.						h. m.	s.	
June 20	− 0.02	− 0.01	− 0.11	− 0.21	− 0.16	14 19	− 48.89	+ 0.48
21	+ 0.02	+ 0.06	− 0.08	− 0.10	− 0.11	14 08	− 48.41	+ 0.86
22	− 3.90	− 3.39	+ 0.20	+ 0.04	− 0.16	15 00	− 47.52	+ 0.56
23	− 3.18	− 3.23	+ 0.30	+ 0.36	− 0.04	14 21	− 46.98	+ 0.68
24	− 3.74	− 3.86	+ 0.07	+ 0.15	− 0.33	14 21	− 46.30	+ 0.51
25	− 4.25	− 3.81	+ 0.12	+ 0.14	− 0.42	14 21	− 45.79	+ 0.50
26	− 3.82	− 3.67	+ 0.05	+ 0.09	− 0.30	14 21	− 45.29	

[Comparison of chronometer and R. S. clock.]

Date.	Negus 1539.	R. S. clock.	Daily rate of R. S. clock.
1883.			
June 20	13 02 00	6 44 21	
20	15 08 47	8 50 40	+318.175
21	14 47 35	8 24 15	+318.255
22	15 40 14	9 11 25	+317.920
23	14 48 40	8 14 45	+317.885
24	14 56 49	8 17 35	+318.123
25	14 49 30	8 05 00	+318.471
26	14 49 38	7 59 50	

Date.	Number of set.	$86636.555 - \left(r + \frac{r}{365}\right)$
1883.		
June 20–21	I–IV	86317.51
21	V	.45
21–22	VI–VIII	.43
22	IX	.65
22–23	X–XII	.76
23	XIII	.79
23–24	XIV–XVI	.80
24	XVII	.62
24–25	XVIII–XX	.56
25	XXI	.31
25–26	XXII–XXIV	.21

San Francisco, Cal.—Pendulum No. 4.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibrations.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 57°.33	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.				*h. m. s.*	*Inches.*	°	*Inches.*							
June 20	I	M.	1	7 18 41.88	1.04	60.40	29.55							
			27	13 10 31.60	.13	56.25	29.55	86104.88	+ .15	+ .60	+ .45	86106.08		
	II		1	13 23 16.70	1.09	56.20	29.55							
			27	19 16 14.80	.15	53.85	29.60	5.57	+ .17	+ .67	−1.06	5.35		
20	III		1	19 28 29.33	1.21	54.20	29.61						86105.96	
21			25	0 54 09.60	.20	58.00	29.64	5.47	+ .22	+ .66	− .56	5.79		
	IV		1	1 04 26.20	1.07	59.45	29.64							
			26	6 42 09.80	.13	61.15	29.62	4.52	+ .15	+ .58	+1.36	6.61		
	V	P.	1	6 55 41.90	1.01	61.25	29.60							86105.92
			27	12 47 22.50	.15	56.60	29.62	4.73	+ .15	+ .60	+ .73	6.21		
	VI		1	12 55 45.10	1.01	56.60	29.62							
			27	18 48 35.70	.14	54.15	29.66	5.41	+ .14	+ .68	− .89	5.34		
21	VII		1	18 58 45.50	1.09	54.20	29.68						86105.87	
22			27	0 51 52.00	.14	56.85	29.70	5.57	+ .16	+ .69	− .83	5.59		
	VIII		1	1 02 36.88	1.06	57.65	29.71							
			27	6 54 21.50	.14	60.50	29.68	4.75	+ .15	+ .63	+ .80	6.33		

San Francisco, Cal.—Pendulum No. 6.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibrations.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 57°.67	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.				*h. m. s.*	*Inches.*	°	*Inches.*							
June 22	IX	M.	1	7 21 11.40	1.08	61.05	29.69							
			37	12 51 04.50	.15	56.60	29.71	86003.66	+ .16	+ .63	+ .51	86004.96		
	X		1	12 59 23.62	1.15	56.20	29.71							
			39	18 48 17.90	.14	53.90	29.74	4.39	+ .18	+ .71	−1.16	4.12		
22	XI		1	18 56 05.40	1.09	54.05	29.75						86004.84	
23			39	0 45 11.40	.15	57.55	29.75	4.57	+ .17	+ .71	− .83	4.62		
	XII		1	0 56 28.00	1.03	59.10	29.74							
			39	6 44 22.10	.12	62.75	29.70	3.49	+ .14	+ .60	+1.44	5.67		
	XIII	P.	1	6 55 07.25	1.09	62.60	29.70							86005.04
			2	7 04 14.62										
			39	12 43 14.50	.13	57.55	29.70	3.72	+ .16	+ .61	+1.07	5.56		
	XIV		1	12 49 43.60	1.02	57.40	29.70							
			39	18 39 00.67	.12	54.80	29.71	4.77	+ .14	+ .68	− .69	4.90		
23	XV		1	18 46 06.80	1.02	54.80	29.72						86005.23	
24			37	0 17 14.40	.12	56.05	29.71	4.99	+ .14	+ .70	− .99	4.84		
	XVI		1	0 26 08.60	1.01	56.65	29.71							
			39	6 14 49.12	.12	61.65	29.67	4.22	+ .13	+ .62	+ .65	5.62		

San Francisco, Cal.—Pendulum No. 11.

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 58°.72	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1883.				*h. m. s.*	*Inches.*	°	*Inches.*							
June 24	XVII	M.	1	6 46 34.20	1.06	63.05	29.68							
			32	12 27 25.20	.13	58.10	29.68	86055.94	+.15	+.59	+.84	86057.52	86057.72	86057.14
	XVIII		1	12 35 05.80	1.01	57.80	29.66							
			33	18 28 42.50	.12	55.00	29.68	7.18	+.13	+.67	—1.04	6.94		
24	XIX		1	18 36 29.90	1.03	54.85	29.69							
25			33	0 31 04.40	.11	57.45	29.68	7.89	+.14	+.68	—1.16	7.55		
	XX		1	0 38 50.00	.98	58.50	29.68							
			32	6 21 39.75	.11	62.25	29.63	7.39	+.12	+.59	+.75	8.85		
	XXI	P.	1	6 32 10.20	.99	62.55	29.63							
			2	6 43 06.30										
			33	12 23 33.00	.12	58.50	29.61	5.28	+.13	+.58	+.81	6.80	86056.56	
	XXII		1	12 34 09.80	.96	58.30	29.61							
			33	18 26 35.00	.11	55.35	29.63	5.93	+.12	+.65	—.85	5.87		
25	XXIII		1	18 35 16.20	.99	55.30	29.64							
26			33	0 28 06.00	.10	58.30	29.66	6.26	+.12	+.66	—.86	6.18		
	XXIV		1	0 35 21.62	1.04	59.30	29.67							
			34	6 37 42.67	.12	64.95	29.65	5.17	+.14	+.56	+1.53	7.40		

WASHINGTON, D. C., 1884.

On my return to Washington in July, 1883, I found the entire east wing of the Smithsonian Institution was being rebuilt, and it was not till March, 1884, that the pendulum room was placed at our disposal. The room is the same in which Major Herschel made his observations in 1882, but is now much better adapted to pendulum work—being less damp, and divided into two rooms so that the apparatus may be in one and the observer in the other observing through a small hole in the intervening door.

In Major Herschel's observations the R. S. clock was attached to the north wall, while in this work it was attached to the south wall. This change was necessary on account of the division of the room and the arrangement of certain steam-pipes in the north wall. Signals were received from the Naval Observatory for ten minutes, beginning at $0^h\ 22^m$ and $12^h\ 22^m$ Washington mean time, the Washington standard clock being used. These signals were recorded on the chronograph with sidereal chronometer, Frods. No. 3477. Immediately before or after these signals the chronometer was compared by coincidence of beats with the R. S. clock, and mean-time chronometers, Negus, No. 1572, and Bond & Sons, No. 196. Corrections to the Washington clock, corresponding to $0^h\ 26^m$ and $12^h\ 26^m$, were furnished by the observatory. They all depend upon observations of transits of stars made near these times except on April 9, indicated by brackets in the table.

The geographical position of this station is, latitude 38° 53′ 19″.6, longitude $5^h\ 08^m\ 04^s.4$; height, 33.9 feet.

Corrections to the Washington mean-time clock as furnished by the Naval Observatory.

Date.	Clock correction.	Date.	Clock correction.
1884.		1884.	
March 26d.018	+ 7s.15	April 3d.018	+ 6s.37
26 .518	+ 7 .11	3 .518	+ 6 .24
27 .018	+ 6 .98	4 .018	+ 6 .28
27 .518	+ 6 .90	4 .518	+ 6 .18
28 .018	+ 6 .98	5 .018	+ 6 .02
28 .518	+ 6 .72	5 .518	+ 6 .04
29 .018	+ 6 .61	6 .018	+ 6 .00
29 .518	+ 6 .48	6 .518	+ 5 .93
30 .018	+ 6 .66	7 .018	+ 5 .81
30 .518	+ 6 .83	7 .518	+ 5 .59
31 .018	+ 7 .01	8 .018	+ 5 .62
31 .518	+ 6 .92	8 .518	+ 5 .55
April 1 .018	+ 6 .86	9 .018	[+ 5 .34]
1 .518	+ 6 .76	9 .518	[+ 5 .13]
2 .018	+ 6 .64	10 .018	+ 4 .92
2 .518	+ 6 .51	10 .518	+ 4 .76

Comparison of Washington mean-time clock with sidereal chronometer, Frods. No. 3477.

Date.	Time by W. M. T. clock.	Time by chron. Frods. 3477.	Correction to W. M. T. clock.	Correction to Frods. 3477.	Rate of Frods. 3477 per sid. minute.
1884.	h. m.	h. m. s.		m. s.	s.
March 26	0 22	0 41 08.81	+ 7.15	−19 01.66	−0.1627
	12 22	12 43 06.24	7.11	20 59.13	
27	0 22	0 45 03.55	6.98	22 56.57	27
	12 22	12 47 00.91	6.90	24 54.01	27
28	0 22	0 48 58.29	6.98	26 51.31	25
	12 22	12 50 55.73	6.72	28 49.01	30
29	0 22	0 52 53.06	6.61	30 46.45	27
	12 22	12 54 50.75	6.48	32 44.27	32
30	0 22	0 56 48.63	6.66	34 41.97	30
31	0 22	1 00 44.23	7.01	38 37.22	29
	12 22	13 02 42.11	6.92	40 35.19	34
April 1	0 22	1 04 39.87	6.86	42 33.01	32
	12 22	13 06 37.60	6.76	44 30.84	32
2	0 22	1 08 35.24	6.64	46 28.60	31
	12 22	13 10 32.93	6.51	48 26.42	32
3	0 22	1 12 30.49	6.37	50 24.12	30
	12 22	13 14 28.22	6.24	52 21.98	32
4	0 22	1 16 25.94	6.28	54 19.66	30
5	0 22	1 20 21.63	6.02	58 15.61	34
6	0 22	1 24 17.32	6.00	62 11.32	32
	12 22	13 26 15.18	5.93	64 09.25	33
7	0 22	1 28 12.94	5.81	66 07.13	33
	12 22	(*)			34
8	0 22	1 32 08.68	5.62	70 03.06	34
	12 22	13 34 06.57	5.55	72 01.02	
9	0 22	(*)			32
	12 22	13 38 01.82	[5.13]	75 56.69	−0.1632
10	0 22	1 39 59.44	+ 4.92	77 54.52	

* Signals from Observatory not received.

Comparison of sidereal chronometer, Frods. No. 3477, with the R. S. clock.

Date.	Time by Frods. 3477.	Time by R. S. clock.	Correction to Frods. 3477.	Correction to R. S. clock.	Rate of R. S. clock per mean solar day.
1884.	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*	*s.*
March 26	0 53 32	0 31 27	−19 03.67	+3 01.33	+70.62
	12 56 30	12 31 52	21 01.31	3 36.69	.52
27	0 59 31	0 32 40	22 58.98	4 12.02	.21
	12 40 19	12 10 40	24 52.92	4 46.08	70.89
28	1 02 21	0 30 05	26 53.49	5 22.51	69.92
	12 47 00	12 12 15	28 48.37	5 56.63	70.16
29	1 05 24	0 28 03	30 48.49	6 32.51	.56
	13 06 52	12 26 58	32 46.23	7 07.77	+70.72
30	0 49 42	0 07 19	34 40.81	7 42.19	
31	0 51 43	0 04 15	38 35.75	8 52.25	+69.35
	12 55 21	12 05 20	40 33.99	9 27.01	.82
April 1	1 17 32	0 24 54	42 35.11	10 02.89	.56
	13 16 38	12 21 28	44 32.47	10 37.53	69.52
2	1 20 51	0 23 08	46 30.60	11 12.40	70.33
	12 59 16	11 59 05	48 24.58	11 46.42	70.07
3	1 30 50	0 28 00	50 27.11	12 22.89	69.83
	13 29 07	12 23 45	52 24.37	12 57.63	+69.72
4	1 09 37	0 01 47	54 18.55	13 31.45	
5	1 30 36	0 17 15	58 17.28	15 03.72	
6	1 35 09	0 16 42	62 13.09	16 13.91	+70.12
	13 41 52	12 20 51	64 11.80	16 49.20	69.97
7	1 16 08	23 52 40	66 05.16	17 22.84	70.10
8	1 48 14	0 19 34	70 05.69	18 34.31	70.03
	13 50 21	12 19 08	72 03.67	19 09.33	70.15
9	13 22 01	11 45 49	75 54.08	20 17.92	+70.43
10	1 52 05	0 13 14	−77 56.49	+20 54.51	

[Number of vibrations of R. S. clock pendulum in mean solar day.]

Washington mean date.	Sets.	86400 − r	Washington mean date.	Sets.	86400 − r
1884.			1884.		
March 26	I–II	86329.38	April 1	XXIII–XXIV	86330.48
	III–IV	.48	2	XXV–XXVI	29.67
27	V–VI	.79		XXVII–XXVIII	29.93
	VII–VIII	29.11	3	XXIX–XXX	30.17
28	IX–X	30.08		XXXI–XXXII	30.28
	XI–XII	29.84	6	XXXIII–XXXIV	29.88
29	XIII–XIV	.44		XXXV–XXXVI	30.03
	XV–XVI	29.28	7	XXXVII–XL	29.90
31	XVII–XVIII	30.65	8	XLI–XLII	.97
	XIX–XX	.18	8–9	XLIII–XLVI	.85
April 1	XXI–XXII	86330.44		XLVII–XLVIII	86329.57

Washington, D. C.—Pendulum No. 4.

[d = 0.9 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 58°.34	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1884.				*h. m. s.*	*Inches.*	°	*Inches.*							
March 26	I	M.	1	0 10 57.1	.91	59.10	27.39							
			27	5 53 15.1	.14	58.85	27.36	86110.80	+ .12	− .07	+ .29	86111.14		
	II		1	6 04 38.6	.84	58.90	27.38							
			2	6 17 48.0										
			27	11 47 12.5	.12	58.55	27.38	0.97	+ .10	− .07	+ .17	1.17		
	III		1	11 58 44.7	1.05	58.65	27.38							
			27	17 41 23.8	.16	58.40	27.38	1.13	+ .16	− .06	+ .08	1.31	86111.24	
	IV		1	17 53 23.8	.97	58.45	27.38							
27			27	23 36 10.0	.14	58.50	27.39	1.20	+ .13	− .06	+ .06	1.33		
	V		1	23 48 41.3	1.07	58.50	27.40						86111.25	
			27	5 31 27.9	.16	58.55	27.40	1.52	+ .16	− .05	+ .08	1.71		
	VI		1	5 41 33.6	.97	58.60	27.40							
			28	11 37 37.2	.13	58.10	27.40	1.58	+ .13	− .05	.00	1.66		
	VII		1	11 46 20.8	1.01	58.15	27.40						86111.27	
			27	17 29 12.6	.14	58.00	27.40	0.89	+ .14	− .05	− .12	0.86		
	VIII		1	17 38 00.8	1.06	58.00	27.40							
28			29	23 47 14.3	.14	58.05	27.43	0.89	+ .15	− .04	− .15	0.85		
	IX	P.	1	0 07 04.2	1.06	58.50	27.45							86110.98
			27	5 48 02.8	.15	58.40	27.96	0.65	+ .16	+ .04	+ .05	0.90		
	X		1	6 01 19.8	1.06	58.55	27.52							
			27	11 42 38.0	.15	58.00	27.50	0.86	+ .16	− .02	− .03	0.97		
	XI		1	11 52 49.5	1.09	58.00	27.51						86110.80	
			27	17 34 16.5	.15	57.65	27.50	0.72	+ .16	− .01	− .24	0.63		
	XII		1	17 44 12.0	1.10	57.60	27.51							
29			28	23 38 49.7				0.77	+ .16	.00	− .22	0.71		
			29	23 52 00.1	.14	58.10	27.54						86110.71	
	XIII		1	0 03 56.7	.99	58.25	27.58							
			27	5 45 32.1	.16	58.75	27.59	0.41	+ .14	.00	+ .07	0.62		
	XIV		1	5 57 10.1	1.04	59.00	27.60							
			28	11 52 01.3	.14	58.55	27.60	0.49	+ .15	.00	+ .20	0.84	86110.62	
	XV		1	12 00 53.0	1.02	58.55	27.60							
			27	17 42 47.3	.14	58.15	27.59	0.45	+ .14	+ .01	.00	0.60		
	XVI		1	17 53 11.7	1.01	58.10	27.58							
30			28	23 48 21.3	.13	57.45	27.56	0.52	+ .14	+ .01	− .26	0.41		

Washington, D. C.—Pendulum No. 6.

[d=0.9 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 55°.12	Corrected number of vibrations in mean solar day.	Means.	Mean of M and P.
1884.				h. m. s.	Inches.	°	Inches.							
Mar. 31	XVII	M.	1	23 39 10.8	1.06	55.50	27.17							
			2	23 48 12.0										
			41	5 40 34.9	.12	55.80	27.19	86012.15	+ .15	− .07	+ .23	86012.46		
	XVIII		1	5 49 08.0	1.10	55.85	27.19							
			40	11 41 29.7	.12	55.75	27.21	2.14	+ .15	− .07	+ .30	2.52		
	XIX		1	11 48 49.8	1.15	55.80	27.22						86012.22	
			39	17 32 09.5	.15	55.50	27.22	1.68	+ .18	− .06	+ .23	2.03		
	XX		1	17 42 08.2	1.10	55.50	27.22							
April 1			42	23 52 34.1	.12	55.15	27.22	1.67	+ .15	− .05	+ .09	1.86		
	XXI		1	23 59 40.8	1.05	55.15	27.26							86012.14
			55	8 07 30.4	.06	55.20	27.28	1.89	+ .12	− .04	+ .03	2.00		
	XXII		1	8 16 38.2	.97	55.25	27.29							
			26	12 02 20.6	.26	55.30	27.29	1.70	+ .18	− .03	+ .07	1.92		
	XXIII		1	12 11 22.1	1.01	55.30	27.30						86012.06	
			37	17 36 38.5	.14	55.20	27.32	1.99	+ .14	− .03	+ .06	2.16		
	XXIV		1	17 45 08.9	1.05	55.25	27.33							
			39	23 28 29.2	.14	55.10	27.33	1.98	+ .15	− .02	+ .03	2.14		
2	XXV	P.	1	23 58 24.8	1.04	55.50	27.15							86012.33
			39	5 42 32.3	.12	55.55	27.16	1.90	+ .14	− .08	+ .18	2.14		
	XXVI		1	5 50 06.6	1.07	55.65	27.16							
			39	11 34 28.7	.12	55.35	27.16	2.13	+ .15	− .08	+ .17	2.37		
	XXVII		1	11 41 44.2	1.01	55.30	27.17						86012.47	
			40	17 35 22.4	.12	55.10	27.17	2.57	+ .13	− .07	+ .04	2.67		
	XXVIII		1	17 42 39.7	1.05	55.15	27.17							
3			42	23 54 33.6	.11	54.85	27.17	2.68	+ .14	− .06	− .05	2.71		
	XXIX		1	0 01 55.3	1.04	54.90	27.19							86012.52
			38	5 37 23.6	.14	55.05	27.22	2.78	+ .15	− .05	− .06	2.82		
	XXX		1	5 45 04.3	1.02	55.10	27.22							
			41	11 47 40.5	.11	54.15	27.20	2.72	+ .13	− .04	− .22	2.59		
	XXXI		1	11 55 47.8	1.04	54.15	27.21						86012.56	
			38	17 31 14.2	.14	53.65	27.22	2.86	+ .15	− .03	− .54	2.44		
	XXXII		1	17 38 54.8	1.08	53.65	27.22							
			40	23 32 25.8	.13	54.15	27.32	2.81	+ .15	− .01	− .54	2.41		

Washington, D. C.—Pendulum No. 11.

[d=0.9 inch.]

Date.	Number of set.	Face.	Number of coincidence.	Time of coincidence by R. S. clock.	Arc of vibration.	Temperature.	Pressure.	Number of vibrations in mean solar day.	Corrections. Arc.	Corrections. Pressure.	Corrections. Temperature to 55°.20	Corrected number of vibrations in mean solar day.	Means.	Mean of M. and P.
1884.				h. m. s.	Inches.	°	Inches.							
April 6	XXXIII	M.	1	0 28 13.2	1.06	56.80	27.08							
			33	6 14 32.8	.14	55.90	27.68	86063.99	+ .15	− .02	+ .52	86064.64		
	XXXIV		1	6 28 11.5	.77	55.95	27.21							
			31	11 53 15.8	.12	55.70	27.69	4.31	+ .09	+ .01	+ .28	4.69		
	XXXV		1	12 07 35.4	1.10	55.75	27.36						86064.78	
			30	17 21 47.0	.17	55.15	27.75	4.42	+ .17	+ .05	+ .11	4.75		
	XXXVI		1	17 32 08.7	1.04	55.15	27.19							
			34	23 30 18.3	.12	55.20	27.77	4.89	+ .14	+ .03	− .01	5.05		
7	XXXVII		1	23 39 41.7	1.02	55.30	27.24						86064.72	
			32	5 15 41.9	.13	55.30	27.79	4.40	+ .14	+ .04	+ .04	4.62		
	XXXVIII		1	5 25 32.2	1.23	55.35	27.28							
			35	11 33 54.6	.13	55.50	27.80	4.30	+ .19	+ .04	+ .10	4.63		
	XXXIX		1	11 44 00.3	1.05	55.50	27.23						86064.65	
			32	17 20 01.9	.14	55.30	27.63	4.42	+ .15	+ .01	+ .09	4.67		
	XL		1	17 29 27.9	1.16	55.30	27.22							
			34	23 27 14.3	.14	55.15	27.60	4.47	+ .18	+ .01	+ .01	4.67		
8	XLI	P.	1	0 01 01.4	1.02	55.95	26.99							
			34	5 58 08.7	.13	55.15	27.22	4.06	+ .14	− .08	+ .16	4.28		86064.47
	XLII		1	6 06 51.1	1.00	55.15	27.34							
			33	11 53 19.6	.13	54.65	27.62	4.19	+ .14	+ .03	− .14	4.22		
	XLIII		1	12 06 01.4	.97	54.65	26.94						86064.16	
			30	17 20 16.9	.15	54.45	27.28	4.30	+ .14	− .07	− .29	4.08		
	XLIV		1	17 28 12.2	1.04	54.45	27.30							
			2	17 39 01.8				4.20	+ .14	+ .05	− .35	4.04		
			34	23 25 40.5	.13	54.40	27.71						86064.22	
9	XLV		1	23 34 34.5	1.24	54.40	27.28							
			34	5 32 09.9	.14	54.80	27.67	4.29	+ .20	+ .04	− .27	4.26		
	XLVI		1	5 43 27.1	1.22	54.85	27.34							
			33	11 30 15.3	.15	55.00	27.66	4.32	+ .20	+ .04	− .13	4.43		
	XLVII		1	11 37 36.0	1.22	55.00	27.26						86064.29	
			31	17 02 45.6	.17	55.00	27.54	4.07	+ .21	+ .01	− .09	4.20		
	XLVIII		1	17 12 37.7	1.22	55.00	27.25							
			37	23 42 51.9	.12	55.35	27.56	4.10	+ .18	+ .01	− .01	4.28		

Results reduced to mean temperature of sets with each pendulum and to density of air under pressure of 26 inches at temperature 32° F., and final reduction to temperature 62° F.

Station.	Number of pendulum.	Number of sets.	Temperature.	Number of vibrations in mean solar day.	Reduction to 62° F.	Number of vibrations in mean solar day at 62° F.	Geographical position.
			°				
Auckland	4	8	63.47	86102.08	+0.67	86102.75	Lat. 36° 51′ 51″ S.
	6	8	62.60	86001.84	+0.27	86002.11	Long. 11^h 39^m 07^s.1 E.
	11	9	63.56	86053.43	+0.70	86054.13	Height 261 feet.
Sydney	4	8	68.56	86087.93	+3.00	86090.93	Lat. 33° 51′ 41′.1 S.
	6	8	69.04	85987.21	+3.11	85990.32	Long. 10^h 04^m 50^s.8 E.
	11	8	69.45	86038.73	+3.35	86042.08	Height 140 feet.
Singapore	4	8	81.77	86012.08	+9.05	86021.13	Lat. 1° 16′ 46″ N.
	6	8	81.61	85911.30	+8.67	85919.97	Long 6^h 55^m 21^s E.
	11	8	82.15	85962.27	+9.07	85971.34	Height 45 feet.
Tokio	4	8	57.82	86101.74	−1.91	86099.83	Lat. 35° 42′ N.
	6	8	58.41	85996.76	−1.59	85995.17	Long. 9^h 19^m 01^s E.
	11	12	60.09	86047.77	−0.86	86046.91	Height 20 feet.
San Francisco	4	8	57.33	86105.91	−2.14	86103.77	Lat. 37° 47′ 22″ N.
	6	8	57.67	86005.04	−1.19	86003.13	Long. 8^h 09^m 42^s.7 W.
	11	8	58.72	86057.14	−1.48	86055.66	Height 375 feet.
Washington	4	16	58.34	86110.98	−1.67	86109.31	Lat. 38° 58′ 19″.6 N.
	6	16	55.12	86012.33	−3.04	86009.29	Long. 5^h 04^m 04^s.4 W.
	11	16	55.20	86064.47	−3.06	86061.41	Height 34 feet.

Differences of pendulums.

Station.	4—6	4—11	11—6
Auckland	100.64	48.62	52.02
Sydney	100.61	48.85	51.76
Singapore	101.16	49.79	51.37
Tokio	104.66	52.92	51.74
San Francisco	100.64	48.11	52.53
Washington	100.02	47.90	52.12

On examining these results it is found that at Tokio the vibration number of pendulum No. 4 is between three and four vibrations too great, and will have to be rejected. I can only explain this discrepancy by the supposition that some foreign material was adhering to the pendulum during these observations. Great care was always taken in wiping the pendulums before suspending them.

The vibration numbers in column 7 on page 58 may be readily reduced to any temperature and density of air and corrected for elevation of station, for comparison with other results. This is not done here, as it is deemed advisable, at present, to publish this work simply as so many additional data to those already obtained with the Kater pendulums, and to make no inference from them till similar data of Major Herschel's work in England and the United States have been received.

I have the honor to be, very respectfully, yours,

EDWIN SMITH,
Assistant Coast and Geodetic Survey.

Prof. J. E. HILGARD,
Superintendent Coast and Geodetic Survey.

Appendix No. 15.

ON THE USE OF THE NODDY FOR MEASURING THE AMPLITUDE OF SWAYING IN A PENDULUM SUPPORT.

By C. S. PEIRCE, Assistant.

The "Noddy" is an instrument invented by Thomas Hardy, a well-known English clockmaker

CORRECTIONS

To Appendices Nos. 15 *and* 16, *Coast and Geodetic Survey Report for* 1884.

APPENDIX 15.

Page 475, line 13, last word: For *they* read *these*.
Page 475, line 23, last word but two: For *or* read *on*.
Page 476 *et seq. passim:* For the upper limit of integration, instead of s read S.
Page 476, 3d and 4th formulæ: For $D_t ds$ read $D_t\theta.ds$.
Page 476, 5th formula: Lower limit of integration is 0.
Page 476, 7th and 8th formulæ: The signs of variation should be signs of partial differentiation.
Page 477, 2d formula: For $D_{ss}\theta$ read $D_s\theta$.
Page 478, 4th formula: For $\mp$ read $+$.
Page 478, 7th formula should read

$$D_t^2\chi_\rho = -\frac{\pi^2}{T^2}\chi_\rho$$

Also in the line above, for χ^s read χ_ρ.
Page 481, 1st and 2d formulæ: The differentiation is in every case relative to t.
Page 482, 5th line from bottom: for $\rho_1 - \rho_2$ read ρ_1 and ρ_2.
Page 482, 2d line from the bottom, 6th word: For *is* read *affords*.

APPENDIX 16.

Page 484, 10th and 13th formulæ: For gmL read gmr.

Pages 484 and 485: The formulæ do not agree with the definition of ψ. They would be right if ω were everywhere substituted for ψ, or if ψ were defined so as to be synonymous with ω.

The M, H, and L of the three last lines of page 484 and page 485 should have been printed in Old English type to distinguish them from the letters used above.

APPENDIX No. 15.

ON THE USE OF THE NODDY FOR MEASURING THE AMPLITUDE OF SWAYING IN A PENDULUM SUPPORT.

By C. S. PEIRCE, Assistant.

The "Noddy" is an instrument invented by Thomas Hardy, a well-known English clockmaker of the early part of this century. It was employed by him and others to detect any oscillatory swaying of a pendulum support, but I use it to measure the amplitude of such swaying. It consists of a little pendulum supported, like an ordinary clock pendulum, from a reed or spring; but instead of hanging down it stands erect, so that gravity acts against the spring and causes the pendulum, although quite short, to oscillate with the same natural period as the gravity pendulum, which hangs from and sways the support. The instrument that was constructed after my design by the late M. Breguet is firmly attached to a brass bed-plate, resting on three screw-feet. The reed is 1 centimeter in length, and from it springs the staff of the noddy, consisting of a steel wire 1 millimeter in diameter and about 9 centimeters long. From the lower part of the staff, just above the attachment of the reed, two short wires extend at right angles to the axis of the staff and in the plane of the oscillation; they have screw-threads cut upon them, and carry short brass cylinders through the axes of which they pass, and which make the principal weight of the noddy. They can be screwed along the wires so as to adjust the equilibrium and alter the radius of gyration about an axis through the center of mass. Another weight, spherical in form, slides upon the staff of the noddy, and serves to adjust the height of the center of mass. There are several sets of cylindrical weights and several sliding weights. At the top of the staff is fixed a small oblong frame carrying a glass scale of tenths of millimeters, the lines being vertical and the scale running in the direction of the oscillatory motion. The scale is 10 centimeters from the attachment of the staff to the reed. A pillar attached to the bed-plate, with its axis in the vertical plane of the reed, carries a horizontal microscope directed toward the scale on the noddy, which is illuminated from an adjustable reflector behind. The microscope is focused with a ratchet; it is furnished with a draw-tube, and carries in the focus of the eye-piece a horizontal scale or glass, each division of which is equivalent to about $0^{mm}.03$ in the focus of the objective as ordinarily used. The noddy is protected from currents of air by being inclosed in a tight metallic cylinder, furnished with two plate-glass windows opposite to one another at the level of the micrometer scale. This cylinder carries the reflector. It is also furnished with a stop-cock, so that the air can be exhausted if desired. The upper ends of the screws of the screw-feet are pointed like the lower ends, so as to serve as feet; and there is a wooden stand with rests for these feet, upon which the whole apparatus can be placed upside down to permit the observation of the period of oscillation of the pendent noddy.

We may first consider the case of the free oscillation of the noddy, and for the present we may neglect all resistance to its motion. Let us assume a system of rectangular co-ordinates having its origin at the root or fixed attachment of the reed, the axis of y being directed vertically upwards and that of x being in the plane of oscillation. The axis of z is then parallel to the axis of rotation, but the motion will be assumed to be in the plane of xy. Let s be the distance of any particle of

the reed from the root; θ, the inclination of the reed to the vertical at the distance s from the root; S, the whole length of the reed; θ_s, the value of θ when $s=S$; θ_0, the value of θ when $s=0$, so that $\theta_0=0$; h, the distance of the center of mass of the noddy from the attachment of the reed; x and y, the co-ordinates of this center of mass; γ, the radius of gyration of the noddy about an axis parallel to that of z and passing through the center of mass; ε, the elasticity of the reed at any point, and we suppose this to be constant throughout the length of the reed; g, the acceleration of gravity; M, the mass of the noddy (that of the reed being neglected); E, the kinetic energy; Υ, the kinetic potency or positional energy. Then

$$x=\int_0^S \sin\theta \,.\, ds+h\sin\theta_s \qquad y=\int_0^S \cos\theta \,.\, ds+h\cos\theta_s$$

$$D_t x=\int_0^S \cos\theta \,.\, D_t\, ds+h\cos\theta_s \,.\, D_t\,\theta_s$$

$$D_t y=-\int_0^S \sin\theta \,.\, D_t \,.\, ds-h\sin\theta_s \,.\, D_t\,\theta_s$$

Let θ' be a quantity which is the same function of a variable s' that θ is of s. Then we have

$$\frac{E}{M}=\tfrac{1}{2}\int^S\left\{ds'\int_0^s\cos(\theta-\theta')\,.\,D_t\theta\,.\,D_t\theta'\,.\,ds\right\}+h\,D_t\theta_s\,.\int_0^S\cos(\theta-\theta_s)\,.\,D_t\theta\,.\,ds+\tfrac{1}{2}(h^2+\gamma^2)(D_t\theta_s)^2$$

$$\frac{\Upsilon}{M}=\frac{E}{M}\int_0 (D_s\theta)^2\,ds+g\int_0^S\cos\theta\,.\,ds+gh\cos\theta_s$$

In the first approximation we neglect the fourth power of θ in comparison with the second, and with this simplification we proceed to form the Lagrangian equations, according to the formula

$$D_t\frac{\delta E}{\delta D_t\theta}+\frac{\delta\Upsilon}{\delta\theta}=0$$

The partial differential coefficients are to be taken on the hypothesis of a change in the value of θ corresponding to a single value of s, all other values remaining unchanged, so that

$$\frac{\delta\int F\theta\,.\,ds}{\delta D_t\theta}=ds\,.\,\frac{\delta F\theta}{\delta D_t\theta}$$

The partial differential coefficient of the first term of $\frac{E}{M}$ is

$$\tfrac{1}{2}\,ds'\int_0^S D_t\theta\,.\,ds+\tfrac{1}{2}\,ds\int_0^S D_t\theta'\,.\,ds'=ds\int_0^S D_t\theta\,.\,ds$$

This does not, however, apply to $\theta=\theta_s$; in that case the whole effect is given by the second and third terms of $\frac{E}{M}$. The partial differential coefficient of the first term of $\frac{\Upsilon}{M}$ is most clearly deduced as follows: Let s_{i-1}, s_i, s_{i+1} be the distances of successive particles of the reed from the root, and let θ_{i-1}, θ_i, θ_{i+1} be the corresponding values of θ. We have

$$s_{i+1}-s_i=s_i-s_{i-1}=ds$$

Let us write

$$\frac{\varepsilon}{ds}=\eta$$

Then that part of the first term of $\frac{\Upsilon}{M}$ which involves θ_i is

$$\tfrac{1}{2}\frac{\eta}{M}(\theta_{i+1}-\theta_i)^2+\tfrac{1}{2}\frac{\eta}{M}(\theta_i-\theta_{i-1})^2$$

and the differential coefficient of this, relatively to θ_i is

$$\frac{\eta}{\mathrm{M}}(-\theta_{i+1}+2\theta_i-\theta_{i-1})=-\frac{\varepsilon}{\mathrm{M}}\mathrm{D}_s^2\,\theta\,.\,ds$$

But when $s=\mathrm{S}$, the first term of the binomial expressing the part of $\frac{r}{\mathrm{M}}$ to be considered is to be struck off, because there is no particle of the reed further from the root; consequently the differential coefficient then becomes

$$\frac{\eta}{\mathrm{M}}(\theta_s-\theta_{s-1})=\frac{\varepsilon}{\mathrm{M}}\mathrm{D}_s\theta$$

We now see that the simplified Lagrangians are

$$\mathrm{D}_t^2\int_0^s\theta\,.\,ds+h\,\mathrm{D}_t^2\,\theta_s-\frac{\varepsilon}{\mathrm{M}}\,\mathrm{D}_s^2\,\theta-g\,\theta=0$$

$$h\,\mathrm{D}_t^2\int_0^s\theta\,.\,ds+(h^2+\gamma^2)\,\mathrm{D}_t^2\,\theta_s+\frac{\varepsilon}{\mathrm{M}}\,\mathrm{D}_s\,\theta_s-gh\,\theta_s=0$$

Differentiating the first of these equations relatively to s, we have

$$-\frac{\varepsilon}{\mathrm{M}}\,\mathrm{D}_s^3\,\theta-g\,\mathrm{D}_s\,\theta=0$$

If we write σ for $\sqrt{\frac{\varepsilon}{\mathrm{M}g}}$, which has the dimension of a line, the solution to the last equation is

$$\theta=\Theta_1\sin\frac{s}{\sigma}+\Theta_2\cos\frac{s}{\sigma}+\Theta_3$$

where Θ_1, Θ_2, Θ_3, are arbitrary functions of the time, independent of s. Since $\theta_0=0$, $0=\Theta_2+\Theta_3$; so that

$$\theta=\Theta_1\sin\frac{s}{\sigma}+\Theta_2\left(\cos\frac{s}{\sigma}-1\right)$$

It thus appears that the figure of the reed is a curve of sines, or a part of such a curve, the wave-length being $\frac{\sigma}{2\pi}$.

We now form from the last equation expressions for θ_s and for $\int_0^s\theta\,.\,ds$, as well as for those terms of the two Lagrangians which involve θ and its derivatives; and from this we eliminate Θ_1 and Θ_2, so as to make the Lagrangians linear equations in θ_s and $\int_0^s\theta.\,ds$. And here it will be convenient to introduce the abbreviations

$$\chi=\frac{\int_0^s\theta\,.\,ds}{\sigma}\qquad \vartheta=\theta_s\qquad \psi=\frac{\mathrm{S}}{\sigma}\qquad p=\sigma\cos\frac{\mathrm{S}}{\sigma}-h\sin\frac{\mathrm{S}}{\sigma}\qquad q=h\cos\frac{\mathrm{S}}{\sigma}+\sigma\sin\frac{\mathrm{S}}{\sigma}$$

The expression just found for θ then gives us

$$-\vartheta+\Theta_1\sin\psi-\Theta_2\,(1-\cos\psi)=0\qquad -\chi+\Theta_1\,(1-\cos\psi)-\Theta_2\,(\psi-\sin\psi)=0$$

$$\frac{\varepsilon}{\mathrm{M}}\,\mathrm{D}_s^2\,\theta+g\,\theta=-\Theta_2\,g\qquad \frac{\varepsilon}{\mathrm{M}h}\,\mathrm{D}_s\,\theta_s=\Theta_1\,\frac{g}{h}\,\sigma\cos\frac{\mathrm{S}}{\sigma}-\Theta_2\,\frac{g}{h}\,\sigma\sin\frac{\mathrm{S}}{\sigma}$$

$$-g\,\theta_s=-\Theta_1\,\frac{g}{h}\,h\sin\frac{\mathrm{S}}{\sigma}+\Theta_2\,\frac{g}{h}\,(h-h\cos\frac{\mathrm{S}}{\sigma})$$

Eliminating Θ_1 and Θ_2 first from the first three of these equations, and afterward from the first two and the sum of the last two, we have

$$\begin{vmatrix} \frac{\varepsilon}{\mathrm{M}} \mathrm{D}_t^2 \theta + g\,\theta, & 0 & , g \\ \vartheta & , \sin\psi & , (1-\cos\psi) \\ \chi & , (1-\cos\psi), & \psi - \sin\psi \end{vmatrix} = 0$$

$$\begin{vmatrix} -\frac{\varepsilon}{\mathrm{M}h} \mathrm{D}_t \theta_t + g\,\theta_t, -\frac{g}{h} p & , g - \frac{g}{h} q \\ \vartheta & , \sin\psi & , (1-\cos\psi) \\ \chi & , (1-\cos\psi), & \psi - \sin\psi \end{vmatrix} = 0$$

We have only to replace the first element of each of these determinants by its value as given by one of the Lagrangians, namely

$$\frac{\varepsilon}{\mathrm{M}} \mathrm{D}_t^2 \theta + g\theta = h\mathrm{D}_t^2 \vartheta + \sigma \mathrm{D}_t^2 \chi \qquad\qquad -\frac{\varepsilon}{\mathrm{M}h} \mathrm{D}_t \theta_t + g\theta_t = \left(h \mp \frac{\gamma^2}{h}\right) \mathrm{D}_t^2 \vartheta + \sigma \mathrm{D}_t^2 \chi$$

to obtain the Lagrangians freed from indeterminate values of s and θ. The two Lagrangians may now be embraced in a single expression by the introduction of an indeterminate number, n. Namely, we multiply the first by $(1-nh)$ and the second by nh, and add, when we get

$$\begin{vmatrix} (h+n\gamma^2)\mathrm{D}_t^2 \vartheta + \sigma \mathrm{D}_t^2 \chi, & -\ ngp, & g - ngq \\ \vartheta & , \sin\psi, & 1-\cos\psi \\ \chi & , 1-\cos\psi, & \psi - \sin\psi \end{vmatrix} = 0$$

The abscissa, x_r, of a particle on the staff of the noddy, at a distance r above the center of mass is

$$x_r = \sigma\chi + (h+r)\vartheta$$

Let ρ be the value of r for a particle so situated that it has a single harmonic motion. Then x^ρ being the abscissa,

$$\mathrm{D}_t^2 x\rho = -\frac{\pi^2}{\mathrm{T}^2} x\rho$$

where T is the period of oscillation. We may give n such a value that the equation combining the Lagrangians becomes identically equal to this, that is, to

$$(h+\rho)\,\mathrm{D}_t^2 \vartheta + \rho \mathrm{D}_t^2 \chi + \frac{\delta^2}{\mathrm{T}^2}(h+\rho)\,\vartheta + \frac{\delta^2}{\mathrm{T}^2}\sigma\chi = 0$$

This gives

$$\rho = n\gamma^2$$

$$\frac{\pi^2}{\mathrm{T}^2}(h+\rho) = g \frac{\begin{vmatrix} 1-\cos\psi, & \psi - \sin\psi \\ -\ np, & 1-nq \end{vmatrix}}{\begin{vmatrix} \sin\psi, & 1-\cos\psi \\ 1-\cos\psi, & \psi-\sin\psi \end{vmatrix}} = g\frac{1-\cos\psi + n(h-q+p\psi)}{\psi\sin\psi - 2(1-\cos\psi)}$$

$$\frac{\pi^2}{\mathrm{T}^2}\sigma = g \frac{\begin{vmatrix} -np, & 1-nq \\ \sin\psi, & 1-\cos\psi \end{vmatrix}}{\begin{vmatrix} \sin\psi, & 1-\cos\psi \\ 1-\cos\psi, & \psi-\sin\psi \end{vmatrix}} = g\frac{n(\sigma-p) - \sin\psi}{\psi\sin\psi - 2(1-\cos\psi)}.$$

I have carefully performed the elimination of ρ and n from these equations, and have thus obtained the quadratic

$$\frac{\pi^4}{g^2\mathrm{T}^4}\gamma^2\sigma\Big[2(1-\cos\psi) - \psi\sin\psi\Big] - \frac{\pi^2}{g\mathrm{T}^2} - (h^2+\gamma^2+\sigma^2)\sin\psi - \sigma p\psi + p = 0$$

The proper adjustment of the noddy requires p to be a very short length. The coefficient of the first term ought also to be small. Then the solution of the quadratic is

$$\frac{\delta^2}{g\mathrm{T}^2}=\frac{1}{2}\frac{(h^2+\gamma^2+\sigma^2)\sin\psi-\sigma p\psi}{\gamma^2\sigma\,(2\operatorname{ver}\sin\psi-\psi\sin\psi)}\left(1\pm\sqrt{1-4\frac{\gamma^2\sigma p\,(2\operatorname{ver}\sin\psi-\psi\sin\psi)}{\{(h^2+\gamma^2+\sigma^2)\sin\psi-\sigma p\psi\}^2}}\right)$$

and the approximate values of the roots are

$$\frac{\delta^2}{g\mathrm{T}_1^2}=\frac{(h^2+\gamma^2+\sigma^2)\sin\psi-\sigma p\psi}{\gamma^2\sigma\,(2\operatorname{ver}\sin\psi-\psi\sin\psi)}=\frac{h^2+\gamma^2+\sigma^2+\mathrm{S}h-\mathrm{S}\sigma\cot\psi}{\gamma^2\,(2\sigma\tan\frac{1}{2}\psi-\mathrm{S})}$$

$$\frac{\delta^2}{g\mathrm{T}_2^2}=\frac{p}{(h^2+\gamma^2+\sigma^2)\sin\psi-\sigma p\psi}=\frac{\frac{\sigma}{h}\cot\psi-1}{\frac{h^2+\gamma^2+\sigma^2}{h}+\mathrm{S}-\mathrm{S}\frac{\sigma}{h}\cot\psi}$$

The latter root represents the principal component of the oscillation. The corresponding values of ρ are

$$\rho_1=-\frac{(h^2+\sigma^2)\sin\psi-\sigma p\psi}{\sigma-p}=-\frac{h+\frac{\sigma^2}{h}-\mathrm{S}\left(\frac{\sigma}{h}\cot\psi-1\right)}{1+\frac{\sigma}{h}\tan\frac{1}{2}\psi}\qquad\rho_2=\gamma^2\frac{(h^2+\gamma^2+\sigma^2)\sin\psi-2\sigma p\tan\frac{1}{2}\psi}{(h^2+\gamma^2+\sigma^2+\mathrm{S}h-\mathrm{S}\sigma\cot\psi)\,(\sigma-p)}$$

For any fixed value of ψ, the first component oscillation will be infinitely rapid when

$$2\sigma\tan\tfrac{1}{2}\psi-\mathrm{S}=0$$

that is, when

$$\tan\frac{\mathrm{S}}{2\sigma}=\frac{\mathrm{S}}{2\sigma}$$

and the second component oscillation will have a period of infinite length when

$$\frac{\sigma}{h}\cot\psi-1=0$$

that is, when

$$\tan\frac{\mathrm{S}}{\sigma}=\frac{\sigma}{h}$$

This affords a means of determining σ, by measuring h when the adjustment is such as to give this condition of things.

The amplitudes of the two component oscillations depend upon the manner in which the noddy is set into motion, but the second will usually be the principal one and the first will be insensible; the noddy will consequently rotate about a fixed point determined by the value of ρ_1.

When the noddy is in the pendent position the vertical co-ordinates may be taken to increase downwards. Then, those terms of $\frac{T}{\mathrm{M}}$ which involve g will have their signs reversed. The equation to determine the figure of the reed will accordingly be

$$\frac{\varepsilon}{\mathrm{M}}\mathrm{D}_s^3\,\theta-g\,\mathrm{D}_s\,\theta=0$$

The solution of this contains gudermannian instead of trigonometric functions, and may be written

$$\theta=-\Theta_1\sinh\frac{s}{\sigma}+\Theta_2\cosh\frac{s}{\sigma}+\Theta_3$$

and since as before

$$\theta_0=0=\Theta_2+\Theta_3$$

this takes the form

$$\theta = -\Theta_1 \sinh \frac{s}{\sigma} + \Theta_2 \left(\cosh \frac{s}{\sigma} - 1\right)$$

This gives us

$$\vartheta + \Theta_1 \sinh \psi - \Theta_2 \left(\cosh \psi - 1\right) = 0$$

$$\chi + \Theta_1 \left(\cosh \psi - 1\right) - \Theta_2 \left(\sinh \psi - \psi\right) = 0$$

$$+ \frac{\varepsilon}{M} D_s^2 \theta - g\,\theta - g\,\Theta_2 = 0$$

$$-\frac{\varepsilon}{Mh} D_s \theta_s - g\,\theta_s - \Theta_1 \frac{g}{h} p^1 + \Theta_2 \left(+\frac{g}{h} q^1 - g\right) = 0$$

where

$$p^1 = h \sinh \psi + \sigma \cosh \psi$$
$$q^1 = h \cosh \psi + \sigma \sinh \psi$$

Thus the Lagrangians become

$$\begin{vmatrix} h\,D_t^2\,\vartheta + \sigma D_t^2 \chi, & 0 & , +g \\ \vartheta & , \sinh \psi & , \cosh \psi - 1 \\ \chi & , \cosh \psi - 1, & \sinh \psi - \psi \end{vmatrix} = 0$$

$$\begin{vmatrix} \left(h + \frac{\gamma^2}{h}\right) D_t^2\,\vartheta + \sigma D_t^2 \chi, & -\frac{g}{h} p^1, & -\frac{g}{h} q^1 + g \\ \vartheta & , \sinh \psi, & \cosh \psi - 1 \\ \chi & , \cosh \psi - 1, & \sinh \psi - \psi \end{vmatrix} = 0$$

and their combination is

$$\begin{vmatrix} (h + n\gamma^2)\,D_t^2 \vartheta + \sigma D_t^2 \chi, & -ngp' & , g - ngq' \\ \vartheta & , \sinh \psi & , \cosh \psi - 1 \\ \chi & , \cosh \psi - 1, & \sinh \psi - \psi \end{vmatrix} = 0$$

The equations to determine ρ and T are

$$\rho = n\gamma^2,$$

$$\frac{\pi^2}{T^2}(h + n\gamma^2) = g \frac{\begin{vmatrix} \cosh \psi - 1, & \sinh \psi - \psi \\ -np' & , 1 - nq' \end{vmatrix}}{\begin{vmatrix} \sinh \psi & , \cosh \psi - 1 \\ \cosh \psi - 1, & \sinh \psi - \psi \end{vmatrix}} = g \frac{\cosh \psi - 1 + n\,(-h + q' - p'\psi)}{2\,(\cosh \psi - 1) - \psi \sinh \psi}$$

$$\frac{\pi^2}{T^2}\,\sigma = g \frac{\begin{vmatrix} -np' & , 1 - nq' \\ \sinh \psi & , \cosh \psi - 1 \end{vmatrix}}{\begin{vmatrix} \sinh \psi & , \cosh \psi - 1 \\ \cosh \psi - 1, & \sinh \psi - \psi \end{vmatrix}} = g \frac{-\sinh \psi + n\,(p' - \sigma)}{2\,(\cosh \psi - 1) - \psi \sinh \psi}$$

The elimination of n gives

$$\frac{\pi^4}{g^2 T^4} \gamma^2 \sigma \{2\,(\cosh \psi - 1) - \psi \sinh \psi\} - \frac{\pi^2}{g T^2} \{(h^2 + \gamma^2 - \sigma^2) \sinh \psi - \sigma p' \psi + 2h\sigma\,(\cosh \psi - 1)\} + p' = 0$$

and the approximate values of the roots are

$$\frac{\pi^2}{g T_1^2} = \frac{(h^2 + \gamma^2 - \sigma^2) \sinh \psi - \sigma p' \psi + 2h\sigma\,(\cosh \psi - 1)}{\gamma^2 \sigma\,[2\,(\cosh \psi - 1) - 4 \sinh \psi]}$$

$$\frac{\pi^2}{g T_2^2} = \frac{p'}{(h^2 + \gamma^2 - \sigma^2) \sinh \psi - \sigma p' \psi + 2h\sigma\,(\cosh \psi - 1)} = \frac{1 + \frac{\sigma}{h} \coth \psi}{\frac{h^2 + \gamma^2 - \sigma^2}{h} - S - s\frac{\sigma}{h} \coth \psi + 2\sigma \tanh \frac{1}{2} \psi}$$

When the noddy stands on the support of a gravity pendulum oscillating in the same plane, we may neglect the influence of the former upon the latter. Then if ξ be the horizontal displacement of the support, we have

$$D_t x = \int_0^s \cos\theta \,.\, D\,\theta \,.\, ds + h\cos\vartheta \,.\, D\,\vartheta + D_t \xi$$

Consequently $\frac{E}{M}$ is increased by the terms

$$D_t \xi \int_0^s \cos\,\theta .\, D_t\,\theta \,.\, ds + h\cos\vartheta \,.\, D_t\,\vartheta \,.\, D\,\xi + \tfrac{1}{2}(D_t\,\xi)^2$$

The first Lagrangian heretofore considered will be increased by $D_t^2\,\xi$, and the second by $h\,D_t^2\,\xi$. The figure of the reed will not be affected, and the combination of the Lagrangians will simply have $D_t^2\,\xi$ added to it. We will now write

$$\xi = \Xi \cos\frac{t}{T'}\pi$$

where Ξ is the constant amplitude of oscillation of the support and T′ is the period of the gravity pendulum. Thus, the differential equation for x_ρ becomes

$$D_t^2\,[(h+\rho)\,\vartheta + \sigma\,\chi] + \frac{\pi^2}{T^2}[(h+\rho)\vartheta + \sigma\chi] - \frac{\pi^2}{T'^2}\,\Xi\cos\frac{t}{T'}\pi = 0$$

This will add to the motion of x_ρ a harmonic component, having the period T′, so that it will be

$$(h+\rho)\,\vartheta + \sigma\,\chi = X\cos\frac{t-t_0}{T}\pi - Q\cos\frac{t}{T'}\pi$$

To determine Q we take the second derivative:

$$D_t^2\,[(h+\rho)\,\vartheta + \sigma\,\chi] = -\frac{\pi^2}{T^2}X\cos\frac{t-t_0}{T}\pi + \frac{\pi^2}{T'^2}Q\cos\frac{t}{T'}\pi$$

$$= -\frac{\pi^2}{T^2}[(h+\varsigma)\,\vartheta + \sigma\,\chi + \frac{\pi^2}{T'^2}\Xi\cos\frac{t}{T'}$$

$$= -\frac{\pi^2}{T^2}X\cos\frac{t-t_0}{T}\pi + \pi^2\left(\frac{Q}{T^2} + \frac{\Xi}{T'^2}\right)\cos\frac{t}{T'}\pi$$

Thus we have

$$\frac{Q}{T'^2} = \frac{Q}{T^2} + \frac{\Xi}{T'^2}$$

or

$$Q = \frac{T^2}{T^2 - T'^2}\,\Xi$$

But the noddy has no oscillation to begin with. This fact is represented by the equations

$$t_0 = 0 \qquad\qquad X = Q$$

Hence

$$(h+\rho)\,\vartheta + \sigma\chi = \frac{T^2\,\Xi}{T^2 - T'^2}\left(\cos\frac{t}{T}\pi - \cos\frac{t}{T'}\pi\right) = \Xi\,\frac{2T^2}{T^2 - T'^2}\sin\frac{T - T'}{2TT'}t\pi\,\sin\frac{T+T'}{2TT'}t\pi$$

This equation shows that the noddy would oscillate with a period, a sort of mean between its natural period and that of the gravity pendulum. The amplitude of oscillation would increase from nothing at an initial rate not much affected by the value of (T — T′) until it would reach its maximum, when

$$t = \frac{TT'}{T - T'}$$

At the beginning the noddy would be a quarter of a phase behind the gravity pendulum; at the maximum oscillation of the noddy it would be in opposition to the pendulum; and when it was reduced to rest again it would be a quadrant in advance. It would then start up as before.

In considering the influence of the gravity pendulum upon the noddy, however, it is essential to take account of the resistance to the motion of the latter, owing to the internal friction of the spring and to the viscosity of the air. The dissipation produced by the former cause will be

$$\frac{1}{2}\mu\int_0^S (D_t\theta)^2\,ds$$

where μ is a constant. This will add the term

$$\frac{\mu}{M}D_t\theta$$

to the first Lagrangian. It will slightly change the figure of the spring, and the equation to determine this will be a partial differential equation, showing that the wave-length will not be constant. But this effect will be very small and may be neglected. Neglecting also the effect of the resistance upon the period of the motion, we find that if the natural motion of the noddy is

$$(h+\rho)\vartheta+\sigma\chi=\Theta\, e^{\frac{t}{2T'}B\pi}\cos\frac{t}{T}\pi$$

then its motion under the influence of the pendulum is

$$(h+\rho)\vartheta+\sigma\chi=\frac{\Xi}{R}\left\{\sin\omega\,.\,e^{-\frac{t}{2T'}B\pi}\cos\frac{t}{T}\pi+\sin\left(\frac{t}{T'}\pi-\omega\right)\right\}$$

where

$$\tan\omega=\frac{A}{B}\qquad R=\sqrt{A^2+B^2}\qquad A=1-\frac{T'^2}{T^2}$$

It will be seen that the natural period and rate of decrement of the arc of the noddy have to be observed, and that weighings and measures of its parts have to be made so as to calculate $\rho_1-\rho_2$. Then, it is necessary to observe, while the gravity pendulum is swinging, the relative amplitude and phase of the motion of the noddy.

I have made considerable use of the instrument, and find it gives results agreeing within a few *per cent.*, and that it is on the whole a tolerably satisfactory way of determining the amount of swaying of a pendulum support.

APPENDIX No. 16.

NOTE ON THE EFFECT OF THE FLEXURE OF A PENDULUM UPON ITS PERIOD OF OSCILLATION.

By C. S. PEIRCE, Assistant.

In determining the acceleration of gravity, it is necessary to consider the effect of the flexure of the pendulum during its oscillation.

Suppose, first, that a pendulum, otherwise rigid, has an elastic joint parallel to the knife-edge and at a distance r vertically below it in the position of repose. Let m_0 be the mass of the piece of the pendulum connected with the knife, m that of the piece jointed to it; h_0 the distance of the center of mass of the first piece below the knife-edge in the position of repose, h that of the second piece below the joint; γ_0 and γ the radii of gyration of the two pieces about axes through their centers of mass parallel to the knife-edge; θ_0 and $\theta=\theta_0+\delta\theta$ the angular displacements of the two pieces about their centers from the position of repose of the whole pendulum. Let ε be the coefficient of elasticity of the joint. With this notation, the kinetic potency* is written

$$U=gm_0 h_0 (1-\cos\theta_0)+gmr\,(1-\cos\theta_0)+gmh\,(1-\cos\theta)+\tfrac{1}{2}\varepsilon\,(\delta\theta)^2$$

If the differential equations were formed, were made linear by the omission of terms of higher degrees, and were then resolved, the motion would be seen to consist of two harmonic components, the amplitudes of which are arbitrary constants. It is, therefore, possible for one of these to vanish, and we may assume such an equation between θ and θ_0 as to bring about this result. This equation must express the condition that the kinetic potency shall be a minimum. It is, therefore,

$$gmh\sin\theta+\varepsilon.\,\delta\theta=0$$

or

$$\delta\theta=-\frac{gmh}{\varepsilon}\sin\theta$$

The elasticity of the joint might be measured by holding the first piece of the pendulum firmly in the horizontal position, while the second piece stood out straight, and measuring the angular flexure at the joint. Denoting this by ω, the last equation gives

$$\omega=\frac{gmh}{\varepsilon}$$

* The term *potential energy* grates upon the ear of a student of Aristotelian philosophy, because both words derive their whole standing in language from that philosophy, and in their proper meanings are directly contradictory of one another. "Energy" means actuality, and "potential" means not yet actualized, so that potential energy is unactual actuality. The conception of half the *vis viva* as an actuality or energy of which the negative of the potential is the corresponding potency or power, seems preferable to the contrary conception that the latter is the real "work" or performance, and the former merely the "power" or *vis* which develops it; because the negative of the potential may subsist for any length of time, but always tends to produce *vis viva*, while the *vis viva* must increase or diminish and does not particularly tend to do either rather than the other. I shall, therefore, venture to call $\frac{1}{2}\Sigma mv^2$ the kinetic act or kinetic energy and the negative of the potential, the kinetic power or kinetic potency. For the sum of the two I can think of no better term than *motivity* or *kinesis*.

Neglecting the square of θ (and *a fortiori* of ω)

$$\delta\theta = -\omega\theta = -\omega\theta_0 \qquad \theta = (1-\omega)\theta_0$$

To find the kinetic energy, we assume a system of rectangular co-ordinates having the origin at the middle of the knife-edge, the axis of y being directed vertically downwards, and that of x sideways, perpendicular to the knife-edge. Then, writing the co-ordinates of the center of mass of the first piece x_0 and y_0, those of that of the second piece x and y, we have

$$x_0 = h_0 \sin\theta_0 \qquad y_0 = h_0 \cos\theta_0$$

$$x = r\sin\theta_0 + h\sin\theta \qquad y = r\cos\theta_0 + h\cos\theta$$

$$(D_t x_0)^2 + (D_t y_0)^2 = h_0^2 (D_t\theta_0)^2 \qquad (D_t x)^2 + (D_t y)^2 = r^2 (D_t\theta_0)^2 + 2rh\cos(\theta-\theta_0) \,.\, D_t\theta_0 \,.\, D_t\theta + h^2 (D_t\theta)^2$$

The kinetic energy is, therefore,

$$E = [\tfrac{1}{2} m_0 (h_0^2 + \gamma_0^2) + \tfrac{1}{2} m r^2] (D_t\theta_0)^2 + mrh\cos\delta\theta \,.\, D_t\theta_0 \,.\, D_t\theta + \tfrac{1}{2} m (h^2+\gamma^2) (D_t\theta)^2$$

Neglecting the square of θ, the differential equations are

$$[m_0 (h_0^2 + \gamma_0^2) + mr^2] D_t^2\theta_0 + (gm_0 h_0 + gm L + \varepsilon)\theta_0 + mrh D_t^2\theta - \varepsilon\theta = 0$$

$$mrh D_t^2\theta_0 - \varepsilon\theta_0 + m(h^2+\gamma^2) D_t^2\theta + (gmh+\varepsilon)\theta = 0.$$

Using the notation

$$A = m_0(h_0^2 + \gamma_0^2) + mr^2 \qquad B = gm_0 h_0 + gm L + \varepsilon \qquad C = mrh \qquad E = -\varepsilon$$

$$G = m(h^2+\gamma^2) \qquad H = gmh + \varepsilon \qquad L = AG - C^2 \qquad M = AH + BG - 2CE \qquad N = BH - E$$

we have the two approximate values

$$D_t^2 = -\frac{N}{M} \text{ or } -\frac{M}{L}$$

If we measure the elasticity by holding the second piece in a rigidly horizontal position and observing the angular sagging at the joint due to the weight of the first piece, we have for the value of this angle

$$\psi = \frac{gmh}{\varepsilon}$$

Substituting we get

$$B = g(m_0 h_0 + mr + mh\psi^{-1}) \qquad E = -gmh\psi^{-1} \qquad H = gmh(1+\psi^{-1})$$

Then

$$M = gmh[m_0(h_0^2+\gamma_0^2) + mr^2](1+\psi^{-1}) + gm(h^2+\gamma^2)(m_0 h_0 + mr + mh\psi^{-1}) + 2gm^2rh^2\psi^{-1}$$

$$\psi M = gmh[m_0(h_0^2+\gamma_0^2) + m(h+r)^2 + m\gamma^2] + gmh\left[m_0(h_0^2+\gamma_0^2) + mr^2 + \frac{h^2+\gamma^2}{h}(m_0 h_0 + mr)\right]$$

$$N = g^2mh(m_0h_0 + mr + mh\psi^{-1})(1+\psi^{-1}) - g^2m^2h^2\psi^{-2}$$

$$\psi N = g^2mh[m_0h_0 + m(h+r)] + g^2mh(m_0h_0 + mr)\psi$$

$$L = m(h^2+\gamma^2)[m_0(h_0^2+\gamma_0^2) + mr^2] - m^2r^2h^2 = m(h^2+\gamma^2)m_0(h_0^2+\gamma_0^2) + m^2\gamma^2r^2$$

If we now write

$$M = m_0 + m$$

$$MH = m_0h_0 + m(h+r)$$

$$MHL = m_0(h_0^2+\gamma_0^2) + m[(r+h)^2 + \gamma^2]$$

and if we denote the period of oscillation by $T+\Delta T$, then when ψ vanishes

$$T=\pi\sqrt{\frac{L}{g}}$$

and

$$(T+\Delta T)^2=\frac{\pi^2}{g}\,\frac{MHL+\left\{MHL+\left(m_0\frac{h_0}{h}-m\right)(h^2+\gamma^2)+mr\left(\frac{\gamma^2}{h}-h\right)\right\}\psi}{MH+[MH-mh]\,\psi}$$

$$\frac{\Delta T}{T}=\frac{1}{2}\left\{\frac{\left(m_0\frac{h_0}{h}-m\right)(h^2+\gamma^2)+mr\left(\frac{\gamma^2}{h}-h\right)}{MHL}+\frac{mh}{MH}\right\}\psi$$

If there are a number of stiff joints, the sum of their separate effects gives their combined effect.

It appears, therefore, that the effect of the flexure of a pendulum upon its period of oscillation is virtually to lengthen it by a quantity which is generally of the same order of magnitude as the amount by which one extremity of the pendulum would sag if the other end were held rigidly horizontal. This must be quite a considerable quantity for all the reversible pendulums which have ever been constructed.

APPENDIX No. 17.

DESCRIPTION OF A MODEL OF THE DEPTHS OF THE SEA IN THE BAY OF NORTH AMERICA AND GULF OF MEXICO.*

[Appendix No. 17 will appear at the end of this volume.]

APPENDIX No. 18.

BRIEF ACCOUNT OF THE EXHIBIT MADE BY THE COAST AND GEODETIC SURVEY AT THE SOUTHERN EXPOSITION, LOUISVILLE, KY.

By H. W. BLAIR, Assistant.

PREFATORY NOTE.

About the middle of July, 1883, Assistant H. W. Blair was instructed to prepare, under the direction of the Assistant in charge of the Office, a collection of instruments and apparatus that should fairly illustrate the several branches of field-work of the Coast and Geodetic Survey, and the methods of work in the Office of Weights and Measures. This collection, together with a set of the publications of the Survey, he was directed to arrange for Exhibition at the Southern Exposition, held in Louisville in the summer and autumn of 1883.

Mr. Blair states that the Exposition, as a whole, was illustrative principally of the manufacturing and agricultural interests of the country, but that there many were fine commercial exhibits and displays of art work, and that the displays of a scientific character were confined mainly to the applications of electricity as a light-producing and as a motive power, and to the exhibits made by the United States Government, in which, besides the Coast and Geodetic Survey, eight other Government bureaus were represented.

The object which attracted most attention in the Coast and Geodetic Survey exhibit, Mr. Blair observes, was the model of the Gulf of Mexico. Several applications for copies of it were received and many special visits were made to it by classes of advanced students, principals of schools, and others interested in geographical and geological studies. Reference is made to this model in Mr. Blair's account of the exhibit of the Survey, and a full description of it, as since enlarged and extended to include the Bay of North America will be found in Appendix No. 17.

At the close of the Exposition two awards were made to the Coast and Geodetic Survey; one of these was a medal for its exhibit as a whole, and the other a diploma for the Line and End Comparator.

For courtesies extended by the manager of the Exposition, Maj. J. M. Wright, and by other officials, and for the assistance rendered and kindness shown by Prof. J. R. Procter, State Geologist of Kentucky, who had general charge of the placing of the Government exhibits, Mr. Blair expresses his high appreciation.

ACCOUNT OF THE COAST AND GEODETIC SURVEY EXHIBIT AT THE SOUTHERN EXPOSITION.

This exhibit shows the principal instruments used in the geodetic, astronomical, topographic, hydrographic, and magnetic work of the Survey, with illustrations of the results of the work shown by a selection of the published charts, a collection of the principal scientific papers, and a relief model of the Gulf of Mexico constructed from data obtained in a thorough hydrographic survey of that body of water. The collection further includes an exhibit from the United States Bureau of Weights and Measures, which is under the care and direction of the Superintendent of the Coast and Geodetic Survey.

Taken in detail the exhibit may be classified as follows:

I. Geodesy.

This department of the work is represented by two theodolites, such as are used in primary and secondary triangulation, and by two varieties of heliotropes.

The larger of the two theodolites has a circle of 16 inches diameter and the limb is divided to 5′ of arc. By three filar micrometer microscopes situated at equal angular intervals of 120°, the circle is read to single seconds, and with the method of observing pursued, the average probable error of a final mean direction measured with instruments of this class is less than 0″.2. In this instrument the circle, spindle, and all working parts are made of iron, greatly reducing the trouble experienced from unequal expansion in the exposure to which the instrument is unavoidably subjected in field use, and which is a serious source of annoyance and error when the theodolite is made partly of iron and partly of brass, or entirely of brass, which has a much higher co-efficient of expansion than iron. The telescope is supported on the improved Fauth & Co. horned Ys, cast in one piece, giving far greater stability than when supported on two pillars. It also has the improved clamp devised by G. N. Saegmuller, chief mechanician of the Survey. The telescope has an aperture of 3 inches, a focal length of 34 inches, and the magnifying power ordinarily used is about 60 diameters. Additional eye-pieces, furnished with the instrument, give other powers greater and less than this. With a theodolite similar to this, and with a telescope equal in size and power, observations were made in California between two points 192 miles distant. This is the longest line ever observed in geodetic work.

The smaller theodolite has an 8-inch circle divided to 10′, and reads to single seconds by two filar micrometer microscopes 180° apart. It has the same style of horned Ys and clamp as the larger instrument. The telescope has an aperture of 1¾ inches, a focal length of 18 inches, and a magnifying power of about 25 diameters. Instruments of this class are used for secondary triangulation where the sides are from 5 to 20 miles in length. The probable error of an observed direction is generally between 0″.3 and 0″.4.

Both theodolites are provided with delicate striding levels and with illuminating lamps for night work.

Heliotropes are used for observing upon stations at which, from distance, smoke, or haze, an ordinary signal pole would be invisible. In their usual form they consist of a mirror or system of mirrors so mounted that when the instrument is directed towards a distant station the sun's rays are reflected by the mirror to that point, and the observer there makes his pointings upon the reflected point of light, as upon an ordinary signal pole. Heliotropes were used with perfect success on the long line above mentioned, and upon several others exceeding 150 miles in length.

II. Astronomy.

This branch of the Survey is represented by a theodolite for azimuth observations, a zenith telescope for latitude work, an electric chronograph for recording time observations, and a break-circuit chronometer. Also by a sextant, which, however, comes more properly under the head of hydrographic instruments.

The theodolite is the larger one above described, and the method usually followed in observing for azimuth is to measure the angle between a terrestrial object and a circumpolar star near eastern or western elongation.

The zenith telescope is used exclusively for the determination of latitude by the Talcott method, which consists in observing stars in pairs, the stars being on opposite sides of the zenith and at so nearly the same zenith distance that the *difference* of their zenith distances may be measured by a micrometer eye-piece. The uncertainty of absolute measures of zenith distance is thus obviated, and the quantities to be measured being small, and the value of the micrometer being capable of the most accurate determination, the resulting error of measurement is a minimum. Also the uncertainty of atmospheric refraction is almost eliminated. With as many as twenty pairs (the usual number) the probable error of the resulting latitude is about 0″.1.

The electric chronograph, in connection with the break-circuit chronometer, makes a continuous time record on a revolving drum. The drum revolves once a minute, being regulated in its movements by a centrifugal governor of a new form devised by the chief mechanician of the Survey.

A pen makes a continuous spiral on the drum, and is in an electric circuit which is broken every second (or two seconds) by the break-circuit chronometer, and the break registers on the chronograph sheet. The end of the minute is marked by the omission (or interpolation) of a break at the fifty-ninth second. The first minute break being noted, the chronograph sheet will make a continuous time record for the time that the chronograph is running. The electric circuit passing through the chronometer and pen passes also to the instrument where the observer is, and is by him broken at the instant of observation, the break registering on the chronograph sheet.

III. Topography

Is represented by a plane-table complete in all its parts and ready for field use. With this instrument and a telemeter rod complete topographical surveys are made, the country being mapped as the field-work progresses.

IV. Hydrography.

This branch of the Survey is represented by a sextant, for the determination of time and latitude at sea and on land, and for hydrographic work for measurement of angles not exceeding 120°; by mercurial and metallic maximum and minimum thermometers, used in taking deep-sea temperatures; two varieties of logs or current meters, for determination of speed of a vessel through the water, or velocity of a current, and by two varieties of salinometers, as used for the determination of the density of sea water. One form is the ordinary float with graduated stem, the density being directly indicated by the depth to which the float sinks. This form cannot be used at sea where the motion of the vessel would prevent the float from settling. For determinations at sea an optical densimeter is used, the construction of which depends upon the refractive index of water. In principle, the apparatus is a spectroscope, the prism being a prism of the water to be examined. The water is held in a triangular bottle. In two sides of the bottle are circular windows closed by pieces of the finest parallel glass. The ray of light passing through these windows passes through a prism whose density changes with the density of the water held in the bottle. The angle of the spectroscope being adapted for the angular refraction by a prism of distilled water, the field of the receiving glass is made such that the *difference* of refraction by distilled water and by sea water may be measured with an eye-piece micrometer. A sodium flame is used, and the object observed is the bright sodium line of the spectrum. The instrumental constants are determined at the outset by experiments upon waters of known densities, after which the simple micrometer readings, corrected for the temperature of the water specimens, give the density. The instrument was devised by Prof. J. E. Hilgard, the present Superintendent of the Survey. It is described and figured in Appendix No. 10, Report for 1877.

V. Magnetics.

The instruments representing this branch of the Survey are a unifilar magnetometer and a dip-circle. The former is used for the determination of the magnetic declination, or variation of the needle, and the horizontal component of the magnetic force. A hollow magnet, having at one end a scale which is in the principal focus of a collimating lens at the other end, is suspended by a single delicate silk fiber. The scale reading corresponding to the magnetic axis is determined by suitable observations. The fiber having been freed from torsion as far as possible, and the magnet being allowed to hang free, it settles into the magnetic meridian, and pointings upon the proper scale division represent pointings upon the magnetic meridian. With a small theodolite attached to the instrument there is measured the angle between the magnetic meridian and any convenient terrestrial mark. The azimuth of the latter from the instrument being determined by other observations, we derive the angle between the true and magnetic meridian, or the magnetic declination. The horizontal component of the magnetic force is deduced from observations of the time of vibration when the magnet is gently drawn from the magnetic meridian and allowed to oscillate freely, these observations being combined with others which indicate the power of the

magnet to deflect from the magnetic meridian another magnet suspended in its place, the former magnet being applied at right angles to the magnetic meridian and at known distances therefrom.

The dip-circle is used for the determination of the magnetic dip which is derived from the direct readings on a vertical circle of a magnet mounted to swing freely in a vertical plane. The vertical component of the magnetic force is deduced from the observed effect of known weights applied near one or the other end of the needle at known distances from its axis.

VI. Publications.

The publications of the Survey are represented by a set of the volumes of the annual reports; by various scientific works, or papers, published separately from the annual reports; by volumes of the Coast Pilot; copies of the annual Tide Tables for the Atlantic and Pacific coasts; a catalogue of upwards of six hundred charts published by the Survey; a selection of the principal copper plates, lithographic, and photolithographic charts, and by a large isogonic chart, in two sheets, of the magnetic declination in the United States.

VII. Miscellaneous.

In addition to the above there is a model of the observing tripod as used in flat or wooded countries, to overcome the curvature, or to elevate a theodolite above trees. The one here shown is a model of one in which the instrument was mounted at a height of 106 feet from the ground.

There is also shown a new form of level bulb, the device of G. N. Saegmuller, chief mechanician of the Coast and Geodetic Survey. The level bulbs are frequently impaired by leakage or by the formation of crystals on the inner surface of the tube. In the ordinary form, where the end of the tube is hermetically sealed, it is impossible to repair or remedy these defects. In the form here shown, one end is drawn to the shape of a neck of a bottle which is ground, and a ground-glass stopper is fitted to it. When the tube is filled the end is closed, and the stopper held in place with a little wax. If trouble occurs from leakage, or from the formation of crystals, it is a simple matter to remove the stopper and fill or clean the tube.

A model of the Gulf of Mexico illustrates the results of hydrographic surveys made in 1876–'78 by the Coast Survey steamer Blake. This model shows in a striking manner the formation of the bottom of the Gulf; the very gradual deepening of the water all along the coast of the United States, except immediately off the mouth of the Mississippi River, where the 100-fathom curve comes within a few miles of land, while off the western coast of Florida (and also off the northern end of Yucatan) this curve is at some points nearly a hundred miles from land. On passing the 100-fathom curve the descent is everywhere very rapid to a comparatively level bottom at a depth exceeding 2,000 fathoms. The narrow and comparatively shallow outlet of the Gulf Stream is forcibly shown, as also the much greater depth of the inlet from the Caribbean Sea.

VIII. Weights and measures.

By custom the English system of weights and measures is ordinarily used in the United States for the purposes of trade and commerce, but by act of Congress the metric system is legalized and is much used in scientific work. The General Government has supplied to each State full sets of weights and measures of each system, and a complete set of both is here exhibited. The customary set comprises a half-bushel, peck, half-peck, and quart, made of brass; a gallon, quart, and pint, made of white metal; weights from 25 pounds to one-quarter ounce and from 500 grains to 20 grains, of brass, and from 10 grains to 1 grain, of aluminium, the series allowing the formation of any combination from 1 grain to 51 pounds; and a yard scale divided to inches and tenths, with a matrix for the comparison of end yards.

The metric set comprises a brass line meter, subdivided to decimeters, centimeters and millimeters, with a tracing apparatus for copying from these onto another bar; a steel end-meter; a brass myriagram, kilogram demi-kilogram and gram, with subdivisions of the latter in platinum; and a brass liter and dekaliter.

The weights and measures exhibit further comprises a delicate comparing apparatus for the micrometric comparison of standard line measures from a decimeter to a meter in length. This

apparatus is made after designs submitted by Mr. H. W. Blair, of the Weights and Measures Office. It consists of what may be called an optical beam compass, by which two powerful micrometer microscopes may be placed at any desired distance apart from a meter to a decimeter. A simple mechanism permits a lateral motion of several inches, longitudinal motion being at the same time restricted to a quantity never exceeding a thousandth of an inch. Beneath the microscopes is a system of roller supports, by which the two bars may be independently supported and separately adjusted and focussed under the microscopes. The bars being adjusted, the beam compass is brought over one of them, being arrested at the proper point by two stops, and micrometer readings are taken on the defining lines of the measure. By a lever movement the beam compass is then moved over the other bar, being again arrested by another pair of stops, and the difference between the bars is measured by the two micrometers. Observations may be repeated with great ease and rapidity. The temperature is noted by thermometers laid upon the bars, and the whole apparatus is covered with a heavy glass case to shield the bars from the effect of the heat of the observer's person. The microscopes have a power of about 60 diameters, and the micrometers are such that one division of the graduated head represents a linear value of one eighty-thousandths (1-80,000) of an inch.

APPENDIX No. 19.

HISTORY OF DISCOVERY AND EXPLORATION ON THE COASTS OF THE UNITED STATES.

By J. G. KOHL, Ph. D.

PREFATORY NOTE.

The historical accounts here given of discovery and exploration on the coasts of the United States were prepared by Dr. J. G. Kohl, a geographer of distinction, at the instance of Prof. A. D. Bache, the Superintendent of the Coast Survey at the time (1854) of Dr. Kohl's visit to this country. But a few years had then elapsed since the beginning of the survey on the Pacific coast, and the want of an authoritative and connected account of early exploration upon that coast was greatly felt. Trustworthy data were needed to establish the origin of geographical names, to decide disputed points of orthography, to identify localities named by early explorers, and to show the condition of discovery and fix the limit of geographical knowledge at various periods.

The work undertaken by Dr. Kohl included, at the request of Professor Bache, in addition to the historical account, a general map illustrating it, a collection of maps showing the range and limits appertaining to each discoverer and explorer, a list of names of bays, capes, harbors, &c., with critical remarks, and a catalogue of books, maps, manuscripts, &c., relative to discoveries.

In so satisfactory a manner was this work performed for the Pacific coast that Dr. Kohl was asked to undertake a similar work for the coast of the Atlantic and Gulf of Mexico. Upon its completion the entire work was deposited for reference in the archives of the Survey. Means for its publication, as a whole, not having been available, it has now been deemed desirable to publish the historical portions in the form of an appendix to this report. To each memoir is appended a list of the collection of maps. Some of these maps are copied from originals, others from old manuscripts or rare prints, and those of more modern origin are of interest as links in the chain of historical connection.

ABSTRACT OF CONTENTS.

History of discovery and exploration on the Atlantic coast of the United States.

The Northmen (982 to 1,347).—Settlement in Gunbiorn's Land or Greenland in 982. Explorations from Greenland to the southwest in the years 1000 and 1001. Also between 1002 and 1007, followed by a settlement in Vinland—supposed to be on Narragansett Bay. Decline of the Scandinavian colonies in Greenland; last expedition to eastern coast of North America in 1347.

Sebastian Cabot (1497).—Voyage to Newfoundland, and thence southwardly—supposed as far as the entrance to Delaware Bay. Delineation of eastern coast of North America according to Cabot on map of Juan de la Cosa in the year 1500.

Ponce de Leon (1512).—Expedition from Porto Rico to the coast of Florida. Other explorers between 1512 and 1519.

Lucas Vasquez de Ayllon (1520–'25).—Voyages to the North American coast; explorations near Saint Helena Sound and a river to the south—supposed the Savannah River. Finds that Florida is a peninsula.

John de Verrazano (1524).—Expedition from Dieppe under the auspices of Francis I, of France. Voyage along the North American coast from the vicinity of Cape Fear, touching at the mouth of the Hudson; thence to the eastward, entering Narragansett Bay, and thence to the coasts of Maine and Nova Scotia.

Esteran Gomez (1525).—Expedition from Corunna to Newfoundland, and thence southward along the eastern coast of the continent. Names given to several localities.

English expedition (1527).—Voyage under the auspices of Henry VIII, of England, towards the coasts of Labrador, Cape Breton, and New England.

Spanish expeditions, Narvaez and De Soto (1528–'43).—Voyages to the Gulf of Mexico; explorations in Florida, Georgia, Alabama, and Mississippi.

Capt. Jean Ribaut, Capt. René de Laudonniere (1562–'65).—Expeditions from Dieppe and Havre to the coasts of Florida, Georgia, and South Carolina.

Sir John Hawkins (1565).—Visit to the coast of Florida and anchorage at the mouth of Saint John's River. Voyage thence to the northeast.

Don Pedro Menendez (1565–'74).—Expedition of discovery and of occupation to Florida; establishment of a colony at Saint Augustine; circumnavigation of the peninsula; voyage to Chesapeake Bay.

Sir Walter Raleigh (1584–'86).—Explorations and settlements in Virginia and North Carolina, under the auspices of Queen Elizabeth, of England.

Capt. John White (1587–'90).—Voyages to and settlement at Roanoke Island.

Bartholomew Gosnold (1602).—Expedition from Falmouth, England. Explorations in the vicinity of Cape Cod and Martha's Vineyard.

Martin Pring (1603).—Voyage from Bristol, England, to the coast of New England to the north of Cape Cod.

Bartholomew Gilbert (1603).—Lands near the entrance to Chesapeake Bay, but is killed by the Indians, and expedition fails.

Sieur de Monts and Champlain (1605).—Expedition from Havre, under the auspices of Henry IV, of France. Explorations on the coasts of Newfoundland, Nova Scotia, Maine, and Massachuetts.

Capt. George Weymouth (1605).—Voyage from an English sea-port to the New England coast. Exploration of Penobscot Bay.

Capt. Christopher Newport (1606).—Expedition fitted out by the London Company for exploration and settlement in "South Virginia." Colony established at Jamestown, Va.

Capt. John Smith (1608).—Examinations of the shores of the Chesapeake to the head of the bay and of the rivers tributary to it.

Capt. George Popham and Capt. Raleigh Gilbert (1607).—Voyage from Plymouth, England, and settlement attempted at Cape Small Point, coast of Maine.

Capt. Samuel Argall (1613).—Breaks up the French settlements on the coast of Maine, from Mount Desert Island to the eastward.

Capt. John Smith (1614).—Publishes a map of Chesapeake Bay; explores the coast of Maine and compiles and publishes a map and description of that coast; also a narrative and map of New England.

Capt. Thomas Dermer, Christopher Levett (1618–'23).—Voyages to the coast of Maine and thence southward; examinations in Long Island Sound and in Chesapeake Bay.

Henry Hudson (1609).—Expedition from Amsterdam under the auspices of the Dutch East India Company. Examinations in Delaware Bay and in the Hudson River.

Cornelius Jacobs May (1614–'23).—Explorations between Cape Cod and Delaware Bay. Founds the first Dutch colonies on the Hudson and Delaware Rivers.

David Pietersz de Vries (1632).—Expedition from the Texel to Delaware Bay; exploration of the low shore of the Delaware peninsula, and examination of the coast between Delaware Bay and the New York entrance.

Brief notice of expeditions of the seventeenth century, concluding with reference to a map showing the outlines of the Atlantic coast, published by Laët, the Dutch cosmographer, in the year 1624.

THE NORTHMEN.

In the early history of Scandinavia it is known that maritime enterprise was a marked characteristic of the inhabitants. At the close of the ninth century some Northmen had passed southward through Italy and Sicily, and after leaving colonies passed across the Mediterranean to the coast of Africa. They founded settlements in France, England, Scotland, Ireland, Iceland, and on the coast of Greenland, and it is probable that one early northern adventurer visited the eastern coast of North America. Doubtless many fables were included in the narratives of their early navigation, but our present concern is with the facts which have led historians to regard Scandinavia as the "*storehouse of nations.*"

The first Scandinavian adventurer who landed on the shores of Iceland was a certain Naddod, in the year 861. Hiorleif, Ingulf, and other Northmen followed in the year 874, and in the course of a century the island was covered with flourishing settlements. Frequent voyages were made from thence to Norway, to Ireland, and to England. In the year 980 one of these Icelandic navigators, Gunbiörn, returned to his country, and stated that he had been driven out of his course so far westward as to have in view a great unknown land. When this report was known, Eirek, who had been an outlaw in Iceland, sailed in the year 982 westward to search for *Gunbiorn's Land.*

He wintered there, returned to Iceland and Norway, and praised the newly discovered land so highly that in subsequent years many Icelanders and Northmen went over to *Greenland* (as Gunbiorn's Land was soon called), and there formed a community. One of the settlers was a certain Heriulf, who had left a son named Biarni at home. The son set out to follow his father, but was driven by stormy weather over to another unknown country, along which he coasted for some time. Finally he turned, reached Greenland, and there his report concerning the new western country was eagerly listened to, and especially by Leif, the son of Eirek, the first settler in Greenland. Lief bought the ship of Biarni, and with it sailed towards the southwest. He found a great rocky country, which he named *Helluland*, *i. e.*, the stony country. This was probably Newfoundland.

Leif, sailing farther to the southward and westward, again made the coast, and named it *Markland* [the country of the woods], and it is supposed to be Nova Scotia. Keeping the same general course, the vessel passed around a far projecting peninsula which was named *Kiliarnas*, *i. e.*, Ship's Nose. This was probably Cape Cod, and the convenient bay in which he anchored is judged to be Narragansett Bay. Leif and his men made on the shore of this bay a small settlement, called Leif's budir, *i. e.*, Leif's cottages. They explored the vicinity, and finding grapes in abundance they applied the name *Vinland*. In the following year, 1001, Leif and his men filled their ship with firewood, and returned to Greenland.

Other expeditions followed. One in the year 1002 was under the command of Thorwald, a brother of Eirek; another in 1005 was conducted by Thorstein; and in 1007 a third set out under Thorfinn Carlsefn. The last named adventurer intended to make a permanent settlement in Vinland. He therefore brought over 160 men. He was accompanied by his wife, Gudrid, and their son, Snorri Thorfinson, was born in Vinland. Gudrid subsequently made a pilgrimage to Rome, and perhaps in that way some knowledge of the western country was spread in Italy.

The Scandinavian colonies of Greenland remained for some years in connection with Iceland, attracted settlers from Europe, flourished, and finally covered a tract of nearly 400 miles along the coast of the peninsula. But activity ceased. After Thorfinn (1007) an expedition went occasionally. It is mentioned that a certain Gudleif Gudlaugson went to Vinland in the year 1028. He is said to have sailed southward to a country which he called Huitramannaland, *i. e.*, the country of white men. Possibly the expeditions of the Northmen from Greenland to the eastern coast of North America were repeated, while the Greenland colonies flourished. The last was according to Rafn, the learned Danish investigator, performed in the year 1347. So this series of expeditions to America can be traced through four centuries, but even the memory of it was lost in the decline of Scandinavian colonies in Greenland. They seem to have been weakened by pestilence, and at times they suffered from the hostile attacks of the aborigines.

SEBASTIAN CABOT, 1497.

After the Northmen, the first European who touched on the Atlantic coast of North America was Sebastian Cabot, son of John Cabot, a Venetian merchant, who was settled in England in the time of King Henry VII. Columbus at the outset of his career had offered his services to the court of England, but there the offer was refused.

Cabot says that the report of the voyage of Columbus "increased in his heart a great flame of desire to attempt some notable thing." He believed, as Columbus did, that the eastern parts of Asia could not be very distant, and therefore he proposed to sail westward in high latitude, or, as he expressed the idea, "because he understood by reason of the sphere that the northwestern route would be a shorter trace to come to India."

The king ordered two caravals to be fitted out, and in the year 1495 issued letters patent, in which he granted to the undertakers and commanders of the expedition the usual rights and privileges "to discover, and conquer for him, the King of England, any yet heathen country, and to occupy it for him and for themselves as his lieutenants, vassals, and governors." In these royal letters Sebastian Cabot, his father, John, and likewise two brothers, are named as the grantees, and hence some writers have inferred that both father and son conducted the expedition across the ocean. But it seems more probable that the wealthy merchant, John Cabot, was named in the

royal letters only because he assisted the expedition with money. Moreover, Sebastian states that his father died previous to the year 1497, in which year the voyage was undertaken.

Cabot sailed westward, keeping along the 50th parallel to Newfoundland, which had been previously known to the Northmen under the name of Helluland. After making land he steered northward, but not finding the desired passage to China he turned south and passed along the coast of what is now known as the New England States. The southern limit reached has been the subject of doubt. Some suppose that he turned at the 38th parallel, but others judge that he went to the vicinity of Cuba. Peter Martyr, Gomara, and other authorities make it certain that he reached the entrance of Delaware Bay.

Hakluyt states repeatedly that Cabot drew maps and wrote reports of his discoveries, but they have been unfortunately lost. We have, however, a delineation of the eastern coast, according to Cabot's report, on the map by Juan de la Cosa in the year 1500. That map confirms the belief already expressed in regard to the southern limit of Cabot's voyage.

Some authors intimate that Cabot made voyages to America in the years 1498, 1499, and 1517, but the particulars of such, if the voyages were made, are not known to us. The Portuguese expeditions across the northern parts of America by the Brethren Cortereal, are of interest only in regard to the Arctic regions.

PONCE DE LEON, 1512.

Sebastian Cabot had "taken possession" in the name of the King of England of the eastern coast of the New World, and in later times the English founded on his discoveries their right to dominion. The Portuguese did not promptly pursue the northern discoveries commenced by the Cortereals. By the Spanish, the exploration of the northern part of Cuba was not taken in hand until the year 1508, and in that year their navigator, Ocampo, circumnavigated that island for the first time.

Excepting the French, Portuguese, and Biscayan fishermen, who, since 1504, yearly went to Newfoundland, we do not know with certainty of any European expedition to the eastern coast of America between the years 1501 and 1512, when Ponce de Leon led in that direction. Some years earlier he had conquered and settled the island of Porto Rico, and held possession there as governor. When deposed, in consequence of some misunderstanding with his officers, and with the court of Spain, he was rich. He was yet in the force and bloom of his life, and he was enterprising. He listened to what was related of unknown countries. The Indians told of a great country called *Cautio*, and of the existence of a fountain or river, *Bimini*, which had the quality of restoring youth and strength to those who bathed in its waters.

Attracted by the traditions, Ponce de Leon fitted out three ships and sailed with them on the 3d of March, 1512, from the harbor St. German, in Porto Rico. He passed along the northern side of the Lucayan Islands, kept a northwestern course, and near Cape Cañaveral saw the coast of the North American continent on the 27th of March (Palm Sunday), which the Spaniards call Pascua Florida de Resurreccion. At first he judged that the land in view was a small island, like one of the Lucayan Islands which he had just left, but he sailed along with the continuous coast in view until the 2d of April, and then applied the name, *La Florida* as well because of the flourishing aspect as also that he saw it first on the Sunday of Pascua Florida. He sought for a harbor, and not finding a good one turned southward.

On the 8th of May Ponce doubled a large cape where the currents gave much trouble, and which he therefore named *Cabo de Corrientes* (cape of the currents), which Herrera puts in latitude 28° 15′ north, and consequently it was Cape Cañaveral. In going southward several small islands were noticed but these cannot be identified, as many inlets have been opened and closed again in the course of time by the action of the sea.

Ponce de Leon doubled the Cape of Florida without attaching a name, and soon after discovered the Florida Keys, or Martires, the Tortugas, and the western coast of the Florida peninsula. On his return voyage to Porto Rico, one of the ships was sent in command of Perez de Ortubia and Antonio de Alaminos toward the northwest to search again for the island and fountain of Bimini. Their report is meager, and no mention is made in it of the coast of Florida. They appear to have sailed only amongst the Lucayan Islands.

Lucas Vasquez de Ayllon was on the coast in the year 1520, but a few years earlier some voyages of secondary interest were made. An English ship is said to have sailed at this period southward from Newfoundland to the Antilles and Porto Rico. Amongst Spanish authors who mention this voyage, Herrera puts its arrival at Porto Rico in the year 1519; others have put it in the year 1517. Herrera, whom we follow, says that "in the year 1519 arrived an English vessel in the island of S. Juan [Porto Rico], which was examined by Spanish officers, and the commander of which stated that they had been for the discovery of a northwest passage or oceanic route to the Gran Can, *i. e.*, to China, from England to Newfoundland, thence southwest to the river Chicora, and that from there they had come in a southern direction to Porto Rico." As the expedition is mentioned as English, some have supposed that Sebastian Cabot was the commander.

Cortes, in the same year (1519), sent out Antonio de Alaminos with dispatches for Spain. He passed through the Gulf of Florida and the Strait of Bahama, but did not land on the eastern coast of Florida, though at several times the land was in view. Passing by the Burmudas he returned to Spain.

Diego Miruelo, a well-known Spanish pilot, doubtless made voyages in these regions on his own account. His movements fill the interval between Ponce de Leon and Vasquez de Ayllon.

LUCAS VASQUEZ DE AYLLON, 1520-1525.

Lucas Vasquez de Ayllon was a Spanish officer eminent by literary attainments. He was some time auditor of the royal court of San Domingo, and had become wealthy in his employment. When laborers became scarce in the Lucayas and in the Antilles, Ayllon, with some others, made an expedition to the north to kidnap Indian slaves. They fitted out two vessels, and Ayllon took command. Diego Miruelo went as pilot. In the course of the year 1520 they followed the track of Ponce de Leon, and passing around the Lucayan Islands they arrived at the shore of a great country, which, by the aborigines, was called *Chicora.* On that part of the coast they named a cape "Cabo de Santa Elena," as it was first seen by them on the day of that saint. This was probably a point of land near Saint Helena Sound on the coast of South Carolina. In that vicinity Ayllon named a river after one of his captains, "*Rio Jordan.*" The extent of the voyage is not well defined, either by Herrera or Oviedo. Barcia says that the party landed at several places, and on nearly contemporary Spanish maps we find the names "Cabo S. Romans," "Riv. Canoas," "Cabo de Trafâlgar," and others that suggest Ayllon as having applied them. It is, however, possible that some of them were not given by Ayllon on his first voyage in 1520, but rather on his second expedition in the year 1525. He went to Spain after his first voyage, and was commissioned by the king to explore, conquer, and settle that promising country. But by reason of various impediments his second voyage was delayed. One of the hindrances will be mentioned. A certain Ortiz de Matienço, also a Spanish civil officer, and like Ayllon, provided with vessels, protested against Ayllon's expedition because one of Matienço's ships had made the same discovery. But Ayllon, notwithstanding the protest, sailed to Chicora. He merely added another name, that of the river "Guale" or "Gualdape," or, as Oviedo writes, "Guadalupe," which is stated as being about 30 miles south of the Point Saint Helena, and possibly it was Savannah River.

In an unfortunate expedition against Indians at some distance from the coast, Ayllon and many of his men were killed. The survivors of the party returned to the Antilles. Previously Florida had been regarded as an island, but the expedition of Ayllon determined its peninsular configuration.

JOHN DE VERRAZANO, 1524.

Christopher Columbus and his brother Bartholomew, before acceptance in Spain, had made propositions to the court of France, and at one time it seemed probable that their offer would be there accepted. French pirates and adventurers were early followers of the Spaniards to the West Indies. After the year 1504 French navigators of Dieppe and other ports of France crossed the ocean to the banks of Newfoundland and returned to Europe with fish.

Francis I was, however, the first French king who sent an expedition specially intended for

the discovery of new lands. The command of it was given to an Italian, John de Verrazano, who belonged to Florence.

At the end of the year 1523 Verrazano sailed from Dieppe with four ships. On his arrival at Madeira, only one vessel, the Dolphin, was found seaworthy, and in that, with fifty men, he started westward. After sailing about 900 leagues by his reckoning, and after being fifty days at sea, he sighted the coast of America in the neighborhood of Cape Fear. From thence he sailed northward, and, following the trend of the coast, must have passed the entrances of Chesapeake and Delaware Bays. Finally he reached a very pleasant place showing steep hills, and an exceeding great stream of water, so deep at the mouth that any great ship might pass up. He entered with his boats, and found the country thickly peopled. Circumstances did not permit him to proceed inland, so he sailed 50 leagues eastward as the trend of the coast was in that direction. From this it seems evident that Verrazano touched the mouth of Hudson River and New York Harbor. For some time the Hudson was called "the river of the hills or mountains." His mention of the trend of the coast eastward makes it certain that Verrazano was the first European who visited the entrance of the Hudson. Sailing along the sea coast of Long Island, he seems to have regarded it as part of the mainland; but in going eastward he soon discovered an island somewhat triangular in outline. This he named L'isle Claudia, in honor of the mother of Francis I. Some authors have judged this to be Block Island, but by others it has been, with more probability, taken as Martha's Vineyard. However that might have been, Verrazano sailed over to a great and commodious harbor or bay, in 41⅔ degrees of north latitude, and there remained fifteen days, trading with the natives and exploring the country. This bay was 20 leagues in circuit and contained five pleasant and fruitful islands, "among the which islands [he says] our great navy may ride safe, without any fear of tempest or other danger." From this description it seems clear that Verrazano had entered Narragansett Bay. It is remarkable that he was at this time the first to mention the name "Island of Rhodes," which afterwards was adopted as a designation.

On the 5th of May, 1524, Verrazano left, and sailing east and then north for 150 leagues, found the coast studded with crags, the shore having many turnings and windings between them, offering fair harbors. He counted thirty-two islands on that part of the coast. Plainly he was then on the coast of Maine. He does not mention the remarkable projection now known as Cape Cod. From the coast of Maine he sailed northeast about 150 leagues, and when off Newfoundland turned back and reached the coast of France early in July, 1524.

It is not known that Verrazano made any maps. In his report mention is made of latitude, and he assigned no names, excepting that of the island Claudia. But he indicates with tolerable accuracy the trending of the coasts and distances. He saw the entire coast from Cape Fear northward to the Bay of Fundy, and his descriptions are tolerable. From what he says, Narragansett Bay and Hudson River entrance can be readily identified. Ramusio says that Verrazano and several of his men were killed by savages; but some Spanish historians record that he was captured in 1524 and hanged by their countrymen.

ESTEVAN GOMEZ, 1525.

The Spaniards advanced slowly towards the north. Previous to the year 1525 not one of their navigators had passed the thirtieth parallel. Ayllon's north limit was the boundary of Spanish research in that direction. Beyond that voyages had been made only by the English, Portuguese, and French; by Cabot, Cortereal, Verrazano, and others. Yet none doubted that there was much land in the higher latitudes. Newfoundland and Labrador were included under the name "*Baccalaos*," and between that and Florida the Spaniards supposed there might be a strait. True, Cabot and Juan de la Cosa had represented the coast as continental, but they did not look into each inlet, nor explore as minutely as Verrazano. Moreover, maps of that period showed an open gap or branch of ocean between Baccalaos and Florida. So, also, years after the voyage of Columbus to Veragua and the Isthmus of Panama, maps showed a *channel*, which it was thought might have been overlooked by that navigator. In the year 1525 the Spaniards fitted out an expedition in the hope of reaching China by a water passage around the continent of North America. Estevan Gomez, who had been with Magellan, was put in charge, and his expectation

was to repeat in a high northern latitude what had been done at the southern extremity of South America. In fact, the notion was then somewhat common that geographical configuration at the north should correspond with that at the south.

Estevan Gomez sailed with one ship from the port of Corunna, at the end of the year 1524, directly over to Baccalaos [Newfoundland], and there turned and passed southward along the eastern coast of North America. There is no journal of his voyage nor copies of maps which he doubtless made. Spanish authors merely allude to the voyage. It is known, however, that he followed the course of his predecessor, Verrazano, merely reversing the order by passing from north to south. Oviedo says that Gomez sailed southward to the fortieth parallel, and that he brought some Indian prisoners home to Spain.

Herrera says: Gomez sailed much further to the southward, and traveled from Florida to Cuba where he remained some time, and then returned to Europe. After an absence of ten months he was again at Corunna in November, 1525. That he brought home a map and description of the country explored is evident from the map of America made by Diego Ribero a few years after. Without doubt he took the configuration of the coast from Gomez, as neither before nor soon after was that part of the coast visited by any Spaniard.

Ribero gives to the entire region the name of the explorer, "*Tierra de Estevan Gomez*," and this may be regarded as the first name applied to New England. It was retained on nearly all maps of the sixteenth century. Gomez Land was the name commonly appplied, until it was displaced by English discoveries.

Two capes marked by Gomez appear on nearly all subsequent maps, namely: "Cabo de Muchas Islas" [cape of many islands] and "Cabo de Arenas," *i. e.* the cape of sand. The first seems to be Cape Elizabeth, on the coast of Maine; the other was either Cape May or Cape Henlopen. The sea between the extreme capes is marked on the map "Archipelago de Estevan Gomez," but on subsequent maps the name of the navigator is omitted. To the northeast of Cape Cod a broad inlet is invariably marked as "Rio de las Gamas" (Deer River), and perhaps it is what is now known as Penobscot Bay.

ENGLISH VOYAGE, 1527

Hakluyt relates (Vol. III, p. 129) that Master Robert Thorne, of Bristol, a man of learning and influence, moved King Henry VIII to encourage discovery in the northern parts of the new world.

Two ships were fitted out, one of them bearing the name Dominus Vobiscum. One of the vessels was wrecked on the coast of Labrador, the other went towards Cape Breton and the coast of New England. After landing to look at the country, the vessel returned home early in October of the year 1527.

SPANISH EXPEDITIONS, 1528–1543.

Estevan Gomez and Lucas Vasquez de Ayllon returned from the eastern coast of North America, one to Spain, the other to the Antilles with miserable Indian prisoners or slaves in lieu of expected riches. But the impression yet remained that wealth might be gained by going further westward and that a region of gold might be reached by passing through the Mexican Gulf. There followed consequently two land expeditions in that direction, one under Narvaez in the year 1528; the other under Fernando de Soto in 1538. The ill-fated expedition of Narvaez was attended by five vessels which carried four hundred men and eighty horses. After landing at Tampa Bay the vessels passed on and the land force perished in the attempt to pass westward along the coast in boats.

De Soto wintered at Apalachee and then marched through territory which is now known as the State of Georgia. His land of promise was "*Cofachique*," a name by which Spanish authors have designated Savannah River. On reaching the country of the Licenciado Ayllon, he found amongst the Indians some iron tools and weapons, probably remains of Ayllon's expedition of 1520 and 1525. The Indians described to De Soto several encounters with Ayllon's men.

Hoping steadily to find in the interior another land like Mexico or like Peru, the party examined the country and probably were in the region now occupied by Pensacola. After two years

of travel and toil, De Soto ended his life in the interior of the Mississippi country. His two captains, Diego Maldonado and Gomez Arias, waited in vain according to his orders, supposing that he might have returned from the interior by another route, but finally they made a series of expeditions along the Atlantic and Gulf coasts, but of these it is probable that detailed reports were not written. Garcilasso, Herrera, and Barcia assert that the expedition went along over the Atlantic coast northward to "*Baccalaos*," and looked into every harbor and every bay in search for De Soto.

In the interval of thirty-six years preceding the French expedition under Ribaut in 1562 there is no record of any Spanish exploration. The maps and geographical descriptions of that period are marked with new names, but we cannot refer them either to Estevan Gomez (1524) or to Ayllon (1520–1525).

The most remarkable description of that time is contained in the second volume of Oviedo's History of the West Indies. We here append a summary; but it is to be regretted that the date of the manuscript is uncertain. We know, however, that Oviedo published the first volume of his history in the year 1535; and that in the year 1557, when he died, the second volume, which contains the description here in question, was ready for the printer.

Oviedo begins his description at the southward with what he calls "*Punta de la Florida*," and that he states as in latitude 25⅔° north. The cape discovered by Ponce de Leon in 1512, and which he named Cabo de Corrientes [Cape of Currents], is called by Oviedo *Cabo de Cañaveral*. But no practical purpose would be met by recapitulating the names given on old Spanish maps to particular places. The "Cape Trafalgar" of that period is our Cape Hatteras. Oviedo methodically states distances from points and river entrances in going northward. Few of the places can be identified, but his description of Saint Antonio River, which is "in a line direct from the north to the south," leaves little doubt that he passed up the *Hudson River*. Estevan Gomez was in that vicinity in the year 1524. From Oviedo's description it is easy to identify Long Island and also Long Island Sound, as well as Narragansett Bay. Excepting Gomez and Ayllon, Oviedo does not name any explorer as affording him knowledge, and it cannot be stated with certainty which of the navigators first saw and named Cape Trafalgar [Hatteras], or Saint Mary's Bay [Chesapeake], or Cape Arenas [Henlopen], and others.

CAPTAIN JEAN RIBAUT.

Admiral Coligny, as chief of the Huguenots, sought an asylum for his persecuted brethren, and with the permission of the King (Charles IX) fitted out two vessels in the harbor of Dieppe. Ribaut was intrusted with the command of the expedition. He sailed on the 18th of February, 1562, and at the end of two months sighted a low cape which he named "Cap François." This was doubtless some object seen on the coast of Florida near Saint Augustine. He went northward from thence, probably because he wished to avoid ground known to be under Spanish dominion. After sailing no great distance he entered a broad river on the 1st of May, and named it "La Riviére de May." This was doubtless the Saint John's. In coasting 60 leagues further he discovered and named eight rivers, giving generally the names pertaining to well-known rivers in France. Finally the vessels entered a spacious sound and found it more commodious than others. This was by Ribaut named *Port Royal*, and there he concluded to make a settlement. He explored the branches, and named them, but the names were not retained on subsequent maps. Some of his soldiers, under command of a Captain Albert, were left in a fort which was named in honor of the King of France, "*Charles Fort*." Ribaut went on to the mouth of Edisto River, and there finding that his provisions were becoming scarce he turned eastward and arrived on the coast of France on the 20th of July, 1562. Civil war then raged in that kingdom, and the little colony on the coast of North America was left without succor. By the efforts of Coligny some vessels were sent to protect the national interests; but in the interval the colony at Charles Fort suffered for want of provisions. Dissensions broke out in the party, and the commander, Captain Albert, was killed by turbulent members in his attempt to quell the revolt. At last they built a vessel, trusted themselves to the ocean, and when in great distress were picked up at sea by an English ship, and thus returned to Europe.

In the year 1564 three vessels were fitted out, and the captain (René de Laudouniere) who had accompanied Ribaut on the first voyage was put in charge of the little fleet, and sailed from Havre on the 22d of April, 1564. He reached the coast of Florida on the 22d of June, and from his description of the landfall must have been near Saint Augustine entrance. The expedition was unfortunate. Most of the companions of the adventurer were killed in contests with the Spaniards. Laudouniere gives the particulars in his "*Histoire Notable de la Floride*," which was published in 1586. Like other commanders of new settlements in America, he encountered mutiny. A party of his men, thinking it better to try some expedition against the Spanish settlements toward the south, seized one of his ships and sailed to Cuba and Jamaica. With the others Laudouniere passed the winter and spring of 1565 in exploring the coast. On the 30th of August the English navigator, Sir John Hawkins, appeared on the coast and anchored at the mouth of May River with four vessels. Hawkins was then on his second return voyage from the West Indies, and had on board a Frenchman who had been with Ribaut in 1562 at Port Royal. At that place Hawkins took in fresh water, visited Laudouniere, and sold to him one of the English vessels. Thus provided, the Frenchman was about to return to Europe, when, on the 28th of August, his former commander, Ribaut, arrived with a force suitable for any ordinary expedition.

SIR JOHN HAWKINS, 1565.

Before relating the particulars of Ribaut's second voyage, it is proper to mention that after Hawkins ranged along the coast of Florida and left Laudouniere, as already stated, the English commander sailed northeast as far as Newfoundland. His voyage is described in Hakluyt's third volume. Doubtless he made a map of this survey, as he was the first English navigator who closely examined the coast of Florida, but the existence of such map is not known.

On his second voyage Ribaut arrived at the river May on the 28th of August, 1565, and only a week later a strong Spanish fleet appeared there under the command of Don Pedro Menendez, with orders from the King of Spain to eject all heretics from the country of Florida, that territory being from olden time regarded as Spanish dominion. The Spanish forces settled at a position a little south of May River and then moved against the small French force under Ribaut and Laudouniere. Jean Ribaut and many others were killed in the attack. Laudouniere and some others escaped in one of the vessels and reached France at the end of the year 1565. Two years later (1567) the French captain, Gourgues, undertook to chastise the Spaniards. His expedition was conducted with courage, and it is remarkable, also, for the quick voyage made by the party.

Gourgues sailed from France on the 22d of August, 1567, with one hundred and fifty soldiers. He reached Florida in October, and in the course of the winter destroyed three Spanish forts at Saint John's River and Saint Augustine Harbor, which were defended by numbers greater than his own. The garrisons were dispersed, but with his limited force, being unable to keep possession for France, he sailed from Florida on the 3d of May, 1568, and after a voyage of thirty-four days landed at Rochelle. But Charles IX of France regarded these expeditions to Florida as being in the interest of Huguenots and favored by Coligny. The King was unwilling to give any offense to the Spanish court, hence no other effort was made from France. The names given by adventurers from that power, with a single exception, "Port Royal Entrance," disappeared from maps of that period.

FLORIDA, 1565–1574.

Don Pedro Menendez de Aviles had distinguished himself as a commander of fleets and expeditions in the service of the King of Spain. A son of de Aviles had served in the West Indies and was finally shipwrecked on the coast of Florida, where he was supposed to be in captivity amongst the savages. The father was permitted to fit out an expedition for search, and was commissioned also to explore the country and to make maps of the bays, harbors, capes, and other geographical features of Florida.

While Menendez was yet in port he had news of the French expeditions of Ribaut and Laudouniere, and it was rumored that a large reinforcement was on the way to Florida. The King of Spain therefore enlarged the fleet and army of Menendez, and directed him to eject all foreigners and intruders from the country in which he was to operate.

Menendez sailed from Cadiz on the 29th of June, 1565, with thirty-four vessels and about three thousand persons. But the ships were separated by storms. The commander, with some of the ships, sighted the coast of Florida on the 28th of August, the day of Saint Augustine. Where the French had settled was not known. They were supposed to be northward, and the fleet moved in that direction. A harbor was entered and explored. Laudouniere, in the year 1564, had named it Riviere des Dauphins, but Menendez called it San Augustin.

Learning from the natives that the French were on the coast farther north, Menendez sailed on and found them at the mouth of the river May, but they avoided his intended attack. Not deeming it advisable to move on their fort without providing defenses on the coast for an emergency, he returned to Augustine Harbor and there erected a fortified camp. Soon after he marched and attacked the French fort "Caroline" by land and killed the greater part of the garrison and settlers. He applied the name San Mateo, and the river May took then the same name. The vigorous pursuit of the French led Menendez to various parts of the region, and he was thus engaged during eight years after the year 1566. He established a small fort not far from Cape Florida, in the Indian province of Teguesto; the fort Santa Lucia, south of Cape Cañaveral, at an indentation which the Spaniards called "Puerto de Is;" the fort in Saint Augustine Harbor; the fort San Mateo, on the river May, *i. e.*, Saint John's River; and the fort San Felipe, at Saint Helena entrance. He dispatched also a captain with thirty soldiers and some Dominican friars as far north as Chesapeake Bay, but that expedition was unfortunate. The party deeming it inexpedient to settle there sailed for Spain.

In the course of nine years Don Pedro Menendez sailed at least twelve times around the peninsula of Florida. The historian Barcia records him as having a more intimate knowledge of the coast than any man before his time. He explored the interior also, along the Saint John's and the Rio Salado, which it was supposed might be a passage toward the East Indies.

Of the expeditions of Menendez the most interesting is recorded in the narrative by his nephew, Pedro Menendez Marquez, who was an able seaman and afterwards a commander of Spanish fleets. The nephew was accompanied by four ships and one hundred and fifty men. Barcia states that the exploration commenced at Cape Florida and was prosecuted northward beyond the entrance to Chesapeake Bay. This bay (says Barcia) is 3 leagues broad at its entrance and it stretches towards the north-northwest, and has many rivers and ports on both sides. His mention of soundings agrees so well with our charts that he must be regarded as one of the best amongst early explorers of Chesapeake Bay.

Menendez died in the year 1574, soon after his return from Florida. His forts and colonies were deserted, and it may be said that with him ended the age of Spanish expeditions on the Atlantic coast.

SIR WALTER RALEIGH.

Queen Elizabeth of England granted to Raleigh, in the year 1584, certain letters patent, nearly in tenor like those granted by Henry VII to Sebastian Cabot; and thus Raleigh was allowed to fit out naval and military expeditions, and to "discover, search, find out, and view such remote heathen and barbarous countries and territories as were not actually possessed of any Christian prince, and to hold them as her vicegerent." This patent was issued on the 25th of March, 1584, and on the 27th of the ensuing April the first expedition, fitted out by Raleigh at his own charge, sailed under his command.

Raleigh had interested in his enterprise some wealthy merchants and other gentlemen, and at their joint cost two vessels were provided with crews. They sailed from the Thames early in the year 1584, under command of Philip Amadas and Arthur Barlow, with instructions to explore the east coast of Florida, and find some convenient place for settlement. As usual at that time, the vessels made for the West Indies entered the Gulf Stream between Cuba and Florida, and then went north and entered some convenient harbor. That they entered Ocracoke Inlet seems probable, as the report says that after entering they sailed 7 miles north to the island of Roanoke. They named the entrance "Wokoken," probably from Indian pronunciation. In fact the first adventurers on the coast of Virginia generally adopted Indian designations. On the first map ot Virginia (by John White) there is only one European name, that of "Virginia."

Amadas, Barlow, and their men did not advance westward into the sound which is now known as Pamplico Sound. They anchored at Roanoke Island. There they had some friendly intercourse with the aborigines, and from them acquired names for the parts of that region. The river which enters the sound, then called the river Neus, bears at this day the name Neuse River. In September, 1584, they returned to England, and their favorable report suggested to Sir Walter Raleigh the proposal that the country should be named "Virginia," which was done in honor of Queen Elizabeth.

Raleigh hastened preparations for an expedition to further explore and make settlements in the country. Seven vessels were fitted out and placed in charge of Sir Richard Grenville. Of the crews, most of the men had been in the earlier expedition, and Captain Amadas accompanied the party. The vessels sailed from Plymouth on the 9th of April, 1585, and, as usual, made for the West Indies and passed in the Gulf Stream to the northern part of Florida. On the 23d of June they were near a cape and were in danger of shipwreck. This was named "Cape Fear," and three days afterwards the vessels anchored in Wocokon Inlet, which is now known as Ocracoke Inlet. Grenville passed seven days in exploring Pamplico Sound. From Hatteras Inlet a colony of one hundred men was sent to Roanoke Island under Master Ralph Lane, and, leaving Master Philip Amadas in general command, Grenville returned, and arrived in England on the 18th of October, 1585.

Lane and Amadas passed the winter of 1585–'86 on Roanoke Island, and in the spring made excursions toward the south and also west and northwest. They explored the expanse now known as Albemarle Sound and also Pamplico Sound, and went as far north as Chesapeake Bay. Doubtless the geographical knowledge thus gained was laid down on the earliest map of Virginia, which is ascribed to John White. It was first published by De Bry, in the year 1590. Ralph Lane introduced the name "Chesapeake Bay." The Indians living on its shores he calls "Chesepians." Albemarle Sound he designates "Sound of Weapomeiock"; the Chowan River, which falls into it, the "River of Chawanaok"; and Roanoke River, as the "River of Moratue." This last he explored in boats to a distance of 60 miles, and supposing that the source was near Mexico, and that by following the channel a passage might be made to the South Sea, he traced it to the mountains in hope of finding silver. Soon after, disputes with the natives brought the colonists into distress. The supplies promised by Raleigh and Grenville did not arrive. Fortunately, Sir Francis Drake, on his return from the West Indies and Florida, inquired, in order to report the state of the colony in England. He offered provisions, and a vessel and boats, but the discouraged colonists requested him to take them home, so the first Virginia colony arrived with Drake at Portsmouth on the 27th of July, 1586.

Meanwhile, Raleigh had dispatched a ship with provisions for the relief of the colony, and soon after three ships under Sir Richard Grenville. All arrived safely not long after the departure of Drake; but finding no one alive at the site of the colony, Sir Richard left fifteen men, provisioned for two years, on the Island of Roanoke. The ships then returned to England. Of these men nothing was heard afterwards. They perished, leaving no record.

CAPTAIN JOHN WHITE, 1587-1590.

This commander, who had been with Grenville, was sent out in the year 1587 with three vessels. At the instance of Sir Walter Raleigh, who provided the means, White was then styled "*Governour of the citie of Raleigh in Virginia.*" White landed the colonists on Roanoke Island, and then returned to England for further supplies. But the Spanish armada was then about to sail for England. All means of defense were needed there, and the colony at Roanoke was of necessity left to its own resources. In the spring of 1590, however, John White again sailed with three vessels, but could find no trace of the Roanoke settlement. The name "Croatan," cut in a tree, was taken as intimating that the colonists had gone there, but White encountered heavy and continuous tempests and was forced to leave the unsafe roadstead at Hatteras. At Roanoke he lost many of his best men, and some boats and anchors. This was the last of a series of unfortunate expeditions to Roanoke. Raleigh and his associates had expended much money, and had fitted out about twenty vessels. More than two hundred colonists perished in the settlement.

COAST OF NEW ENGLAND, 1602–1605.

After the time of Verrazano and Estevan Gomez (1524–'25) and the voyage of the English ships in 1527, we know not of any expedition to the shores of New England until the year 1602. The French expeditions under Cartier and his successors were confined to the region of Canada. The voyage of Sir Humphrey Gilbert was intended for the acquisition of Newfoundland, but was unfortunate. His vessel, when returning, foundered at sea, on the 12th of September, 1583. At that period many French, Portuguese, and English fishermen resorted to the same quarter, but nothing was thus added to geographical knowledge. The maps were such as were given by Gomez and Verrazano; and the coast was designated generally as Norumbega. A great river was marked with that name, but on some maps "Rio de Gamas," *i. e.*, Deer River. The island "Claudia," mentioned by Verrazano, was graphically conspicuous; but the configuration of the coast was very erroneously represented; on some, so prominent a feature as the Bay of Fundy is not shown. By Spaniards the region was mentioned as the "Northern parts of Florida." The French named it "Nouvelle France"; and after Raleigh's expedition the English styled it as the "Northern parts of Virginia."

After White's unfortunate voyage in 1590, twelve years elapsed without further action on this part of the Atlantic coast.

GOSNOLD AND GILBERT, 1602.

Capt. Bartholomew Gosnold sailed in a small bark, with thirty-two men, on the 26th of March, 1602, from Falmouth, England. From the Azores he steered due west, but all preceding navigators, in sailing for America, shaped their course for the West Indies. He reached the coast in the vicinity of the forty-third parallel, and there his men took great numbers of codfish. The nearest cape received at that time the name "Cape Cod," and the Indians were found in possession of some European implements. Gosnold, sailing southward, passed the island ot Nantucket, but went ashore at the next and named it "Martha's Vineyard," because, as he says, it abounded in strawberries and other fruits. He found also deer and other animals. In crossing to the mainland he passed several small islands. His men were willing to remain, but not being well provided, they sailed eastward, and arrived in England on the 23d of July, 1602.

MARTIN PRING, 1603.

Soon after the return of Gosnold, the mayor of the city of Bristol (John Whitson), the historian Richard Hakluyt, and other gentlemen, formed acompany and fitted out two vessels, which were placed in command of Martin Pring. He was accompanied by Robert Salterne, who had been one of Gosnold's pilots. The vessels reached the coast of America somewhat north of the forty-third parallel. The country seen was high and covered with woods, and hence the landfall was certainly north of Cape Cod. It was probably in the neighborhood of Penobscot Bay. He named an island "Fox Island," and going southwest he entered several rivers, and finally passed into Cape Cod Bay, which had been missed in the preceding year by Captain Gosnold. After lading his vessel with sassafras, which was an object of trade with the first explorers of the coast of New England, Pring sailed eastward and reached home in October, 1603.

BARTHOLOMEW GILBERT, 1603.

An ineffectual attempt was made by Captain Samuel Mace, in 1602, to settle in Virginia. In that year Bartholomew Gilbert had been with Gosnold to seek out the position of the settlers left in those parts by Sir Walter Raleigh in the year 1587, but he was unfortunate. He landed near the entrance of Chesapeake Bay, but was slain by Indians, with his principal men. So, without effecting anything in the way of exploration, the vessel returned to England in charge of Master Henry Sute.

SIEUR DE MONTS AND CHAMPLAIN, 1605.

Henry IV of France commissioned the Sieur de Monts, a very enterprising navigator, to conquer and settle the countries in La Nouvelle France between the 40th and 46th parallels of

latitude, and to him the King issued a commission as lieutenant-general of such territory in America.

De Monts sailed on the 7th of March, 1604, from Havre, and by the usual route of French vessels reached Newfoundland, Campseau, and l'Acadie [Nova Scotia]. He continued westward, and finally passed southward to the 40th parallel. Passing around Cape Sable he entered what was then called "La Baye Françoise," but which is now known as the Bay of Fundy. On the 24th of June (day of John the Baptist), he entered a river mouth, and hence the name. One of his officers examined the river to a distance of 50 leagues. From the St. John River, De Monts, who on this voyage was accompanied by the Sieur Champlain, went 24 leagues further westward and entered Passamaquoddy Bay. They settled upon an island in Schoodic River, and named it "*Isle de St. Croix*."* After deciding to winter in the place, the larger vessels were sent to France. The winter being severe, it was deemed expedient to seek a place for settlement further southward, but it seems probable that they went no further than Penobscot Bay. The configuration of the entrance, in the descriptions of De Monts and L'Escarbot, is compared to the figure of the Greek letter *Lambda*. Further west De Monts entered another large river which the Indians called "*Kinibeke;*" and in the same direction a bay was entered and named "La Baye de Marchin," after a French officer. This no doubt is what is known as *Casco Bay*.

Near Cape Cod the party remained for some days, and gave it the designation "*Cape Malebarre*." But, being then short of provisions, the vessels returned to St. Croix. De Monts was succeeded by the Sieur du Pont, who fitted out a vessel at Port Royal, in Nova Scotia. He was thrice driven back by storms, and in a third attempt the bark was wrecked. The crew was saved, but the disaster brought to a close French enterprise on the coast of New England.

CAPTAIN GEORGE WEYMOUTH, 1605.

Early in the reign of James I of England, maritime research was active. Two of the patrons of that period were Thomas Arundel, Baron of Wardour, and Henry, Earl of Southampton. They employed Weymouth and fitted out for him a vessel with the requisite provisions, and a crew of twenty-nine men. Weymouth sailed from England while De Monts was near the Bay of Fundy, and both navigators passed along the eastern coast of America. The first named came within sight of the coast near Cape Cod in the middle of May, 1605, and anchored in what he calls "Pentecost Harbor," because it was entered on Whitsunday, as stated in Captain Smith's narrative. The coast was high and studded with islands, and high mountains were seen in the interior. This Pentecost Harbor is supposed to be the mouth of St. George's River. The island lying out seaward Weymouth named St. George Island. There Weymouth planted pease, barley, and garden seeds, and early in June, 1605, explored Penobscot Bay, which in the same year the Frenchman, De Monts, had examined and named Pentagoet. In the middle of June Weymouth sailed for England.

CAPTAIN CHRISTOPHER NEWPORT, 1606.

The expeditions of Gosnold, Pring, Weymouth, Gilbert, and others, were fitted out by separate companies, but these were by order of the king (James the First) placed under the same General Council of Government. He declared that Virginia belonged to England by old and later discoveries, and that explorations had been extended from the 34th to the 45th parallel of north latitude. By royal order the region was to be regarded as divided between North Virginia and South Virginia, the division line being about midway between the 30th and 40th parallels. The exploration and settlement of South Virginia he committed to the London Company; North Virginia was given to the so-called Plymouth Colony, and ample privileges were granted to both.

In August, 1606, the London Company sent out a vessel in command of Henry Challons, but he was seized by the Spaniards. At the end of the same year the same company fitted out three ships and provided them with means for a plantation. The expedition was intrusted to Captain Christopher Newport and sailed from England on the 19th of December, 1606. As usual the course was by way of the West Indies. Southern entrances were at that time regarded as bad harbors,

* Now called Neutral Island. See Williamson's History of Maine.

but Chesapeake Bay from the time of the earliest Spanish navigators was in esteem for safety, and is so represented on the map of the neighborhood of Roanoke drawn in the year 1590. On the 26th of April, Newport entered the bay and named the south side of the entrance "Cape Henry," in honor of the English prince of that name. The bay was sounded and some of the river mouths. Near one of the anchorages the land was named "Point Comfort," but what is now "Newport News" was by him designated "Archer's Hope." Passing 8 leagues further up the river a little settlement was made and was named "Jamestown" in honor of the King. The building of the fort there was commenced on the 14th of May, 1607. Ten days afterward a cross was erected and the name "King's River" was applied. Captain Smith calls it "Powhatan River," after the noted chieftain, but it is probably the same river which was previously known to Spaniards, and which they had marked as "Rio del Espiritu Santo." In the middle of June the fort at Jamestown was complete. Captain Newport left at the settlement 104 persons and then returned to England.

In the early experience of the colonists dissensions were frequent, but all matters there eventually came under the control of a man of more than ordinary ability, and moreover of adventurous spirit.

CAPTAIN JOHN SMITH, 1608.

Smith had served as an officer in the Austrian army, against the Turks, and had traveled much abroad. When the two companies were formed for colonization in Virginia, Smith became interested and accompanied Newport. By the King he was named as one of the councillors of the new colony. When the settlement at Jamestown was deemed secured, Smith led in succession exploring parties toward the interior, and finally, in the spring of the year 1608, made an exploration of the shores of the Chesapeake Bay. At this time nothing was known respecting either its extent or its direction. With an open barge Smith set out from Jamestown on the 2d of June, 1608, with 14 persons. He was accompanied by Walter Russell, a physician.

Smith, from the mouth of James River, crossed the bay and began the examination at Cape Charles. The first island on which they landed was named "Smith's Isle," and from thence he passed along the eastern shore of the bay, towards the north. The next group of islands was named "Russell's Islands." These are in Tangier Sound. Sailing further he named a group "Limbo Isles," and a point south of these was marked "Point Ployer." Crossing to the western shore the party examined the Patuxent and the Patapsco, but his men were then tired of hardships in an open barge. Smith was constrained to return without having seen the head of the bay or settling the question whether it did or did not lead towards China. On the 16th of June they entered the Potomac and went up as far as the draught of the boat would allow, probably as high up the stream as the site of Washington or Georgetown. He then returned, entered the Rappahannock, and explored its course. Near by he was wounded in the hand by a fish, and to mark the place he applied the name "Stingray Island," which holds in the vicinity at this day.

On the 21st of July Smith was again at Jamestown, but on the 24th set out again along the western shore of the bay and soon reached the head. He entered the Susquehanna, which he named after the Susquehannocks, an Indian tribe settled on its shores, and he must have passed well into what is now the State of Pennsylvania, as he marks part of the river as "Smith's Falls." Another branch of the bay he named Tockwough, and it is, probably, Sassafras River.

The Indians along the Chesapeake mentioned to Smith that another great water existed beyond the hills, and he judged it to be a lake or river of Canada; but it seems more likely that the Indians referred to Delaware Bay and River.

After exploring the principal branches of the Chesapeake, Smith again reached Jamestown on the 7th of September, 1608. He states that the aggregate of water courses examined was about 3,000 miles. His map of the region is creditable in point of accuracy, and was copied many times in the century following his time. He was elected president of the colony and held office until the autumn of the year 1609. By an accidental explosion of gunpowder he was wounded and felt himself constrained to return to England. After his departure no action wss taken in furtherance of his wishes in regard to exploration. He had been previously on the coast of New England, and hence his name will be again mentioned in this paper.

CAPTAINS POPHAM AND RALEIGH GILBERT, 1607.

The Plymouth Company made an attempt to settle a colony in the year 1606, as had been done by the London Company. In the interest of the first-named company Captain Thomas Hanham went to New England and explored the havens and harbors, but no details can be found respecting his movements. But, in the following year, the same company fitted out two ships and sent in them a hundred men under command of Capts. George Popham and Raleigh Gilbert. They sailed from Plymouth on the 31st of May, 1607, and passing westward made land at Monhegan Island on the coast of Maine. Near by, they entered a navigable river named Sagadahock and there formed a settlement; but finding the place inconvenient they moved to Small Point, a few miles west of the mouth of Kennebec River. When preparations were complete for winter the vessels sailed on the 5th of December for England.

The winter proved to be unusually severe and the settlers suffered in consequence of the cold. Moreover, the Indians were hostile. George Popham and some others died. In the spring of 1608 other vessels arrived with supplies, but the colonists were already discouraged and concluded to return to England. The death of a brother in England necessitated the departure of Gilbert.

In England the returning North Virginian settlers gave unfavorable reports respecting the region and represented that it was uninhabitable for Englishmen.

CAPTAIN SAMUEL ARGALL, 1613.

Mention has already been made of the coast voyage by De Monts in the year 1605, and of the unfortunate attempt by the Sieur du Pont in 1606. The French still regarded themselves as owners of the coast, though of late years the English had visited the region oftener. In the year 1608 the Fathers Biard and Masse went to Nova Scotia, but soon disagreed with the French governor, and sought another place for settlement. On Mount Desert Island they constructed and fortified a habitation, planted, and passed some years. Five years later they were joined by thirty of their countrymen, who founded a settlement of the name of Saint Sauveur, which was sometimes called Mount Mausell. But, by the English this French lodgment was considered an intrusion on their Virginian possessions. Captain Argall was therefore sent to displace the intruders. He had accompanied other commanders, and hence had large experience in coasting. In the year 1613 he went in charge of a vessel, and was engaged in taking fish when a storm forced him to enter Penobscot Bay. At Mount Desert he found the French settlement of Jesuit missionaries and plundered it, and also seized the only French ship then in the harbor. Fifteen Frenchmen were made prisoners and taken to Virginia, and there the fact that any foreign settlement had been made caused much anxiety. The Governor immediately placed three armed vessels under command of Argall, and he went north to operate against the French, as far as Acadia. At Mount Desert he destroyed all vestiges that remained after his hostile visit, and set up on the island the arms of Great Britain. Passing on to Saint Croix River and the Bay of Fundy, all traces of French habitations there and also at Port Royal were scattered. He then returned to Virginia. In English publications and maps what had been and is now marked as the Bay of Fundy was for a long period marked as *The Bay of Argall.*

CAPTAIN JOHN SMITH, 1614.

Captain Smith left the Chesapeake region in the year 1609, went to England, and was there active in promoting further settlements on the coast of America. He was regarded as a great authority in such matters by leading men of the day. In the year 1612 he published his map of Chesapeake Bay, accompanied by a description of the country, and thus favored the views and interests of the London Company. Doubtless the Plymouth Company desired similar advantages, as they soon engaged Smith to go out with two ships, in company with Captain Hunt. The vessels sailed promptly and made land at Monhegan Island on the coast of Maine. There the crew was busy taking in a cargo of fish, while Smith with a few hands went in boats along the coast as far south as Cape Cod. Three months were passed in making his survey. He entered nearly every bay and harbor, procured the names of Indian tribes, villages, and localities; observed for longitude and latitude, and after his return to England (August, 1614) compiled a

map and description. This was issued in the year 1820. In the interval, however, Smith made (in 1615) another attempt to reach America. He sailed from England in March, but was captured by French men-of-war and detained as a prisoner at Rochelle. When liberated, Smith returned to England and there passed the remainder of his life in publishing his works. His first narrative and map of New England was issued in the year 1616; and in token of their regard the members of the Plymouth Colony conferred on him the honorary title of "*Admiral of New England.*" He says that he applied the name (*New England*) in opposition to the French, as their "New France" adjoined, and as, moreover, they included Northern Virginia. On the western side of the continent, under the same degree of latitude, Sir Francis Drake had landed and named a country *New Albion*. Smith applied many new names, but in the course of time they were disused. He says that when constructing his map several others, less accurate, were in his hands. The latitudes assigned by Smith are good; and the longitudes are better approximations than were recorded by either of his predecessors.

Captain Thomas Dermer sailed from England in the autumn of the year 1618 and went westward to Monhegan Island. His vessel there tookin fish and furs, and returned to England. Dermer remained on the coast of New England, and in a small bark passed southward to some part of Virginia in search of a mine reported to be there. He passed into Chesapeake Bay, and, as he says, "Discovered many goodly rivers and exceedingly pleasant and fruitful coasts and islands for the space of eighty leagues from west to east, between Hudson River and Cape James, *i. e.*, Cape Cod." Neither maps nor journals were left by Dermer. He left only a short letter giving a summary of his voyage from the coast of Maine south to Chesapeake Bay. He went southward on the 19th of May, 1619, touched at Plymouth Harbor, passed around Cape Cod, and staid some time at Martha's Vineyard. In Long Island Sound he found a "dangerous cataract amongst small rocky islands, occasioned by two unequal tides." This mention marks the condition of Hell Gate at that time. He passed through New York Bay and went south to Cape Charles, where he anchored and made a map. After his return to the north he wrote a narrative of the voyage, but nothing is now known respecting the details of either the map or the journal.

Christopher Levett was sent out from England by authorities claiming the province of Maine in the year 1623. He landed at the Isles of Shoals, and from thence coasted in boats to the eastward as far as the Kennebec; but on being told by the Indians that no place in that direction was favorable for settlements, he returned to his vessel.

HENRY HUDSON, 1609.

At the end of the year 1608 the Dutch East India Company engaged the English navigator Henry Hudson, who had gained reputation by his energy at sea. They gave him a small vessel, The Half Moon, and commissioned him to explore the waters north of Europe and Asia, to find, if possible, a short northern passage to the East Indies. He had been twice employed in such service by certain murchants of London.

Hudson sailed from Amsterdam on the 25th of March, 1609, with a crew of Dutch and English sailors, and passed by the north coast of Europe towards Asia. But he was beset by fogs, storms, and icebergs, and was unable to reach the well-known island of Nova Zembla. It was deemed best to turn westward, and at the Banks of Newfoundland be turned towards the south, and traversed the New England coast. At Penobscot Bay he went ashore, and also at Cape Cod. Keeping on southward he passed the entrance of Chesapeake Bay, and from the latitude of 35° 41′ N. he turned back. The dry journal of Juet says nothing in regard to Hudson's intentions. Cleveland, in his Life of Hudson, expresses the opinion that Capt. John Smith, a personal acquaintance, had informed Hudson of his own belief in the existence of a western passage to the south of Virginia. Not finding any such passage he turned northward, and coasted along the series of sandy islands outside of the peninsula of Delaware. He remarks "the coast is a white sandy shore, and sheweth full of bays and points, and all within the land to the northward the water ranne with many islands in it."

Passing along to Cape Henlopen, he entered, on the 28th of August, Delaware Bay.* He

* See "Historical inquiry concerning Henry Hudson, By John Meredith Read, jr." Published at Albany, N. Y., in the year 1866.

sounded, wrote a description, and embodied sailing directions, thus recording the first mention of any consequence after the examination by Oviedo in the year 1545. If maps were drawn by Hudson, they were not preserved. He sounded along the coast of New Jersey, and in his journal mentions the islands and inlets. On the 2d of September he had in sight the hills of Navesink, and says "they are a very good land-mark to fall with and a pleasant land to see." He describes Sandy Hook, but named it *Colman's Point*, because one of his men (John Colman) was wounded there by an Indian arrow, and died. On the 11th of September Hudson passed the Narrows and entered New York Bay. Finding that the water soon freshened, the passage was regarded as a river, and he passed up to the site now occupied by the city of Albany. Laet says that Hudson named the river "*Manhattes*" after an Indian tribe that lived near the entrance.

On the 4th of October Hudson sailed for England. The Dutch East India Company, seeing the probable importance of his discovery, sent out vessels to that region, but the only narrative of these several expeditions now known is that of De Vries, in the year 1632. After the time of Hudson, the region was explored by Adrian Block and Hendrick Christiansen, but the routes they followed, and even the year of their voyage, are uncertain. It was probably between the years 1610 and 1612. Both of these commanders were on the shores of New Belgium for the second time in the year 1614, with five ships. Block then explored the East River and passed through Long Island Sound. He sailed up the Connecticut River to the site now occupied by the city of Hartford.

The East India Company annually, until the year 1618, sent out some ships, but at the date mentioned the privileges of the company expired. Private voyages were made to the region of the Hudson until the year 1621, when the West India Company was chartered, and two years later expeditions went out and soon gave names which appear on the early Dutch maps of that quarter.

Cornelius Jacobs May, in the year 1614, was with Block and Christiansen in the New Netherlands. He was again sent out in the year 1623 by the West India Company, and took the lead of marine affairs for the States General, and also for New Netherlands, on the Hudson River. Under the direction of the company, May led the first Dutch colony to settle along the Hudson. He explored eastward as far as Cape Cod, and from thence passed southward and entered Delaware Bay, which he called the "South River in the Southwest." His countrymen named lower New York Bay "the Port May;" Delaware Bay they marked as "New Port May," and its entrance capes, "Cape May" and "Cape Cornelius." Hudson, in the year 1609, had entered, but turned without passing into the bay. May stopped in the Delaware at the site of Philadelphia, and near it established the first Dutch settlement, and for its defense built Fort Nassau.

DAVID PIETERSZ DE VRIES, 1632.

De Vries led an expedition to Newfoundland and another to the East Indies. At his return to Amsterdam in the year 1631, he formed with Samuel Godyn and other Dutch merchants a company for exploring and settling on the Delaware River (then known as South River) and for whale fishing in that vicinity.

The company sent out a vessel under Captain Peter Heyes to South River, and at the mouth a small fort was built. But the enterprise was not successful. Only one whale was taken, and the garrison of thirty men was unable to resist an Indian attack, and all the defenders were killed.

In the following year De Vries arrived in person with two vessels. He sailed from the Texel on the 24th of May, 1632, and reached the entrance of the Delaware on the 3d of December. The vessels anchored near a place which he calls Swanendael, and there a settlement was commenced. With one of the vessels the river was examined and names were given to several localities, as, "Reed Island," "Wyngaert's Hill," "Vogelsant," "Swanendael," "Timmeokill," and others, but these names soon disappeared as later maps were drawn.

After taking a few whales De Vries made a visit to the English settlement in Virginia, and on his course explored the low shore of the Delaware peninsula. He returned from Virginia and was again at South Bay on the 29th of March. The crew of the vessel left there had, in his absence

taken nine whales. That vessel was sent laden to Hudson River, and with the smaller one he closely examined the coast, but no map is attached to his account of the coast features. From Hudson River De Vries returned to Amsterdam, and arrived there on the 24th of July. Between the years 1636 and 1642 he made a third voyage to New Netherlands, but the particulars bear only on the early history of the State of New York. Nothing was thereby added to our knowledge of coast hydrography.

The development of the eastern coast of the United States in regard to essential features became known in a short period by the expeditions of French and English to the shores of New England; by voyages of the Dutch to Hudson River and vicinity; and by the English to Chesapeake Bay and vicinity early in the seventeenth century. Laet, the Dutch cosmographer, was able, in the year 1624, to publish a map showing the outlines and coast details with considerable accuracy.

Titles of copies of maps of the Atlantic coast of North America or parts thereof.

[Published between the years 1500 and 1770, and collected by J. G. Kohl, Ph. D.]

No.	Description of map.	Year
	A series of maps (Nos. 1 to 16, inclusive) under the general title of the "East coast," as follows:	
1	By Juan de la Cosa	1500
2	From a map in the edition of Ptolemaeus	1508
3	By Diego Ribero	1529
4	From a map in Ptolemaeus	1530
5	From an Italian map	1534
6	From a map of the world by Baptista Agnese	1534
7	From a map of the world by Diego Homem	1541?
8	From an English map of J. Rotz	1542
9	From the Ptolemaeus of Ruscelli	1544
10	From a French map by N. Vallard	1547
11	From a French map (author unknown)	1550
12	From a map of America by A. Joan Bellero	1554
13	From a manuscript map of Oxford	155?
14	A map by the Portuguese geographer D. Homem	1558
15	A map by Diego Gutierrez, a Spanish cosmographer	1562
16	From an old manuscript atlas in the British Museum	156?
17	Le Moyne's map of Florida	1565
18	Italian map of the east coast by Zattiery	1566
19	The east coast from a map of Joannes Martines	1578
20	Map of the east coast by Fernando Simon	1580
21a	The east coast after Michael Lok	1582
21b	Map of Virginia, by De Bry	1590
22	The east coast from Molineux's Globe	1592
23	General map of the east coast by Wytfliet	1597
24	(This number does not occur either on the maps or in the explanatory notes)	.....
25	Virginia (more particularly Chesapeake Bay) by Capt. John Smith	1608
26	New England, by L'Escarbot	1609
27	New England, by Capt. John Smith	1614
28	New Netherlands. From a Dutch map, the original in the archives of the Hague	1616
29	French Florida, by L'Escarbot	1618
30	A map of the greater part of the east coast by Capt. John Smith	1624
31	"Ould Virginia," by R. Vaughan after Captain Smith	1624
32	A general chart of (part of) the east coast of North America, by J. de Laët	1624
33	New England, by Joannes de Laët	1630
34	Coast of Florida, by de Laët	1624
35	New Belgium or New Netherlands, by Lucini	1631

Titles of copies of maps of the Atlantic coast of North America or parts thereof—Continued.

No.	Description of map.	Year.
36	The south part of New England, by William Wood	1634
37	The first map of Maryland	1635
38	The New Netherlands, by Andriaen van der Donk	1656
39	New Jersey, by John Seller and William Fisher	1676
40	Carolina, by W. Hack	1684
41	A chart of the Gulf Stream, by Dr. B. Franklin	1769 to 1770
	[NOTE.—Dr. Kohl has observed that the first map on which any notice at all is taken of the Gulf Stream is the one copied by him from a manuscript of John Dee in the British Museum and bearing date of 1580. See No. 15 of the collection of maps relating to the Gulf of Mexico. The first delineation of the course of the Gulf Stream on a chart of the Atlantic is the one which Franklin had engraved from data furnished by Captain Folger, of Nantucket, and which he had published by Mount and Page, Tower Hill, London. Dr. Kohl's copy of this map bears no date, but that given above (1769-'70) is taken from Franklin's own account of its origin.]	
42	Boston harbor, by Henry Popple	1733
43	New York and Perth Amboy Harbors, by Henry Popple	1733
44	The town and harbor of Charlestown in South Carolina, by the same	1733
45	The harbor of Saint Augustine, by the same	1733
	[NOTE.—The copies of maps above named are deposited in the archives of the Coast and Geodetic Survey. There is also on file in the archives a map of the discovery of the East Coast of the United States, compiled by Dr. Kohl to illustrate his historical account, and showing by colors the range and limits appertaining to each discoverer and explorer.	

ABSTRACT OF CONTENTS.

History of the discovery and exploration of the Gulf of Mexico.

Columbus (1492-1502).—Sails westward from the Isle of Pines, discovered by him in 1494. On his fourth voyage, 1502, is again in the western part of the Gulf.

Sebastian Cabot (1497).—Touches on the continent and passes southward along the coast.

Solis and Pinzon (1506).—Reach the coast of Honduras and sail northward; how far is uncertain.

Sebastian de Ocampo (1508).—Examinations on the coast of Cuba.

Juan Ponce de Leon (1512).—Examinations on the eastern and western coasts of Florida, and in the approaches to the Gulf of Mexico.

Diego Velasquez (1511-'14).—Leads an expedition for the conquest and settlement of Cuba.

Diego Miruelo (1516).—Voyages from Cuba to Florida.

Cordova (1517).—Expedition from Havana, Cuba, to the coasts of Yucatan.

Grijalva and Alaminos (1518).—Expedition fitted out at Matanzas, Cuba, for the exploration of the coast of Yucatan and of Mexico.

Fernando Cortes (1519).—Commands the expedition fitted out at Havana and intended to make a thorough examination of the coasts of Yucatan and Mexico. Founds a colony at Vera Cruz, and enters upon the conquest of Mexico.

Alvarez (1519).—Expedition fitted out under the direction of the governor of Jamaica. Examines the west coast of the peninsula of Florida, and sails thence to Vera Cruz.

Narvaez (1520).—Commands an expedition fitted out by Velasquez to proceed to Vera Cruz, and obtain the submission of Cortes to the authority of Velasquez.

Pineda and Camargo (1520).—Under the auspices of the governor of Jamaica an expedition is fitted out for a settlement at Panuco on the Mexican coast.

Ponce de Leon (*second expedition* 1521).—Expedition from Porto Rico to the Gulf coast of Florida.

Francisco de Garai (1523).—Receives from the King of Spain a grant of the government of a province on the western coast of the Gulf of Mexico.

Narvaez (1527-'36).—Expedition starting from San Lucas in Spain for the purpose of exploration and settlement on the northern shores of the Gulf of Mexico.

De Soto (1539).—Expeditions to the Gulf of Mexico. Exploration and settlement between Tampa Bay and Apalachee Bay.

Diego Maldonado (1540).—Makes report to De Soto of his discovery of and entrance into Pensacola Bay.

De Soto (1541).—Discovers a great river which the Spaniards named Rio Grande, but named subsequently the Mississippi.

Luis de Moscoso, Maldonado, and Arias (1542–'43).—Continuation of the explorations set on foot by De Soto. Expeditions to the country south and west of the Mississippi, and descent of that river to the Delta.

Andres de Ocampo (1543).—Explorations and travels in the regions between Mexico and Florida.

Andres de Olmos and Guido de las Bazares (1558).—Expedition from Vera Cruz for the examination of the whole of the north shore of the Gulf, to find a harbor suitable for the fleet of Don Tristan de Luna.

Don Pedro Menendez (1563–'67).—Commands an extensive expedition to the Florida coasts; is made Captain-General of Florida, breaks up the French settlements on the peninsula, makes examinations and surveys on both the Atlantic and Gulf coasts.

French and English adventurers (1555–'67).—Voyages and explorations by Robert Tompson, Sir John Hawkins, Captain William Michelson, and others.

Pedro Menendez Marquez (1573).—Commissioned to make a survey of the coasts of Florida.

Ruiz, Lopez, Antonio Espejo and others (1551–'83).—Explorations in New Mexico, Texas, and adjacent regions. Name given to the province of New Mexico; settlement of Santa Fé.

Robert de la Salle (1682–'85).—Plans an expedition to complete the work of exploration of the Mississippi River. Descends the river to the Delta, and sounds out and explores the Passes.

Juan Enriquez Barrato (1685).—Commands an expedition to the north coast of the Gulf, and examines the bays and capes from Pensacola Harbor to the westward.

Andres de Pes (1693).—Enters Pensacola Bay, examines its shores and indentations, and gives names to its prominent capes, &c. Proceeds thence to Mobile Bay and to Lake Borgne.

Iberville (1698–'99).—Lands with an expedition under his command at Dauphin Island; takes soundings in the vicinity, names Biloxi Bay and Pascagoula River, also Lakes Manrepas and Pontchartrain.

De Tonti (1700–'04).—Having accompanied La Salle in his several expeditions, and having passed four times up and down the Mississippi, dies at Mobile Bay.

St. Denis (1714–'19).—Under the direction of M. Crozat, manager of the French colony in Louisiana, traverses Texas and Mexico; returns to Mobile, and prepares maps of the Mexican Gulf countries.

Lemoyne de Bienville (1717–'20).—Sends out expeditions under his direction as governor of Louisiana to establish settlements and military posts on the north coast of the Gulf. Founds a colony in 1718 on the present site of new Orleans. Arrival of Father Laval, a French astronomer of distinction, who determines latitude at a station on Dauphin Island.

Bernard de la Harpe (1721).—Commands an expedition for establishing French settlements on the coast of Texas.

Father Charlevoix (1722).—As an explorer, and as the historian of early times in the northern region of the Gulf of Mexico, occupies a conspicuous place.

French and Spanish commanders on the Gulf coast and on the peninsula of Florida (1718 *and later*).—Contests for the possession of Saint Joseph's Bay, Pensacola Harbor, and other points on the Gulf coast between French and Spanish commanders.

U. S. Coast Survey (1846).—Geodetic operations on the coast of the Gulf of Mexico begun by the United States Coast Survey.

COLUMBUS, 1492–1502.

On his first arrival in the western hemisphere Columbus regarded as islands all the land then seen. No chart of that time is extant, except what may be considered as such in the armorial bearings ordered by the King of Spain at the end of May, 1493. Spotorno gives a fac-simile of the map, and Oviedo makes mention of it. He says: "On this chart are seen islands lying *in a gulf* which is formed by *tierra firme* of the Indies, and upon the *tierra firme* of the chart are represented palm trees, other evergreens, and gold clumps."

On his second expedition Columbus sailed along the south shore of Cuba, and early in June, 1494, was at the Isle of Pines, and beyond it he sailed some distance. Strangely, he regarded the region as being part of the East Indies, and turned without discovering Mexico. On his fourth voyage (in July, 1502), Columbus was again in the western part of the Gulf, but did not reach Yucatan. He never touched on the mainland of the continent of America.

SEBASTIAN CABOT, 1497.

The continent was touched on by Cabot on the 24th of June, 1497. This was previous to the third voyage of Columbus. From his western landfall he passed along the coast southward, but the limit reached in that direction is somewhat uncertain. The only early chart marked with the discoveries of Cabot is that of Juan de Cosa, of the year 1500, referred to by Humboldt and Walkenaer. On it Cuba is represented as an island, and the continental shore line runs to the north and to the west of Cuba.

JUAN DIAZ DE SOLIS AND VINCENTE YAÑEZ PINZON, 1506.

In 1494 Columbus had intimated that no passage was practicable around the coast of Cuba, and his declaration seems to have checked somewhat the progress of discovery in that region. The effect was to divert attention to the southward and westward, and thus the outline of the Caribbean Sea became known while the north and west shore of the Gulf of Mexico was yet unexplored.

Solis and Pinzon sailed from Hispaniola and reached the coast of Honduras. Fernando Columbus says they had a pilot, Pedro de Ledesma, who had been in the same region with Christopher Columbus. They sailed along the cost of Honduras and steered northward, but the limit of their navigation cannot be marked with certainty. In the biography of his father, Fernando Columbus says that Solis and Pinzon made a chart of the newly discovered regions, but no copy of such chart is known to us.

SEBASTIAN DE OCAMPO, 1508.

Herrera says (in 1507) that King Ferdinand of Spain regarded his officers as delinquent, because so many years had elapsed without settling the question as to the insular character of Cuba. He therefore sent an order to his Governor-General of the West Indies, Don Nicolas de Ovando, to fit out an expedition. Two vessels were sent under Captain Sebastian de Ocampo, who had been with Columbus in voyages to Hispaniola. The navigation was difficult, and the vessels needing repairs, a port was entered on the northwestern coast of Cuba, and there some time was passed in refitting. The place he designated as Puerto de Carenas [harbor of careening], but it is not doubtful that the port was Havana. Ocampo sailed along the south coast of Cuba, going eastward. Near the Isle of Pines he crossed the track followed by Columbus in 1494, and returned to Hispaniola after being eight months at sea. There is no complete journal nor record of nautical and astronomical observations made by Ocampo, but he was certainly the first man who discovered the prospective importance of the harbor of Havana.

In the year 1512 Diego Velasquez marched in the interior of Cuba, and Ponce de Leon, sailing from Porto Rico, traversed part of the shores of that great island. In the year following, a map was printed in Europe, showing to the northwest of Cuba a gulf and a peninsula, and it was probably an attempt to represent Florida and the Gulf of Mexico. The map is given in the Strasburg edition of Ptolemaeus, of the year 1513. On it is depicted to the northwest of Cuba a continent marked with the name Parias, which designation was somewhat common on early maps of the American continent. The author of the map here especially referred to was John Schott. At that time such publications were suppressed in Spain. The map has no reference to Ponce de Leon, nor is it marked with the name Florida, nor with any other, pertaining to his adventures. He regarded Florida as an island, and it is so represented on the map.

On a chart of the year 1508 Cuba is marked as an unfinished discovery, showing only part of the northern and part of the southern shore, and it bears the inscription, "So far came the ships of King Ferdinand of Spain." Evidently the parts shown were such as had been seen by Columbus. Ruisch, the compiler of the map, knew nothing of the map of Cosa, which was made in the year 1500.

Near the end of the year 1510, or possibly some months later, a vessel went from Hispaniola for the capture of Indians. Thirty men were on board. By a storm the vessel was forced into the Gulf of Florida, and was wrecked. All the crew were killed by the natives, excepting two women and one man, who were given as slaves to a cacique of the Indian district near Havana. There the captives lived until liberated at the time of the conquest of the island of Cuba, by Diego Velasquez. The port in which the misfortune happened, was afterwards called Puerto de Matanzas [port of slaughter], and it still bears the name.

Velasquez landed in 1511 and reached the middle parts of the island in about two years. He learned that Spaniards were held by the Indians, and hastened to liberate them. The survivor assured Velasquez that he had been held nearly four years.

In the year 1511 a vessel was despatched from the Isthmus of Darien, commanded by Captain Valdivia, to bring a sum of gold, and to report the state of affairs to the Governor-General. Unfortunately this vessel was wrecked on some rocks on the south side of Jamaica. Valdivia and

some of the crew in a boat attempted to reach the coast of Cuba, but were swept westward by the currents, and landed in Yucatan. There they were held by the Indians; some were killed and others were kept as slaves. The only survivors were Geronimo de Aguilar and Gonzalo Guerro. These were alive when Cortes arrived in Yucatan, in 1519, and the first-named, having acquired the language and much knowledge of the country, became useful to the daring adventurer.

JUAN PONCE DE LEON. 1512.

The Indians found on Cuba had a tradition of a country to the northward named "*Cautio*," where was a river of which the waters would restore youth. As Ocampo passed eight months of the year 1508 in that vicinity it seems probable that his report was known to Ponce de Leon, who, for some time, was governor of the island of Porto Rico. But a similar story was told of a fountain on an island called "*Bimini*," to the northwest of Hispaniola. Three years later the governor was superseded, but he had become wealthy, and fitted out at his own cost three vessels, and with them sailed on the 3d of March of the year 1512 from Aguada, at the mouth of the river Guanabo. In the middle of the month he was at Guanahani, where Columbus had landed. He crossed the track of Columbus and advanced to the northwest. On the 27th of March, which was a festival day, called by the Spaniards "el Dia de Pascua Florida de Resurreccion," he saw the coast of a new country, which he regarded as an island, and this he named "*La Florida*" He coasted some distance, but finding no harbor turned back, as the current was strong. With some difficulty he rounded Cape Cañaveral, and going southward reached the Florida reefs and keys. On the western coast of the peninsula, at a place which cannot readily be identified, the vessels remained until the 3d of June. Next day they were attacked by a great fleet of canoes. Many Indians and a few of the Spaniards were killed, hence the place was named Isla de Matanza; *i. e.*, the island of slaughter. For some days, however, intercourse was maintained with the natives. Passing on westward, they reached the *Tortugas* on the 21st of June, and there they caught in a single night one hundred and sixty large turtles. They killed also seals, pelicans, and other birds which there abounded. Three days afterwards they sailed, and again saw land on the 26th. At the end of the month they entered a harbor to repair the vessels, but could learn nothing of the country to which it pertained. By most of the party it was believed to be part of Cuba, as some iron tools were seen, and trees that had been cut by knives. Moreover the trend of the coast was east and west. On Friday, the 1st of July, they left the harbor and brought up at some islands of the Lucayan group. There they sought for the island of Bimini, and met with a Spanish vessel commanded by Diego Miruelo, who was sailing on his own account. Much was expected from his experience as a pilot in that dangerous quarter, but the vessel in which he had joined the fleet of Ponce was soon wrecked in a storm, but without loss of life. The family to which Miruelo belonged afterwards became famous as Gulf pilots.

Ponce decided to sail homeward, but before starting despatched a vessel to renew the search for Bimini. This was commanded by Juan Perez de Ortubia and the pilot, Antonio de Alaminos. Bimini was found, but nothing was seen of the wonderful fountain. The place was, however, reported to be a cheerful, fresh-looking island, well watered, and full of trees. Herrera adds to his report on this expedition a chapter on the nature and currents of the Gulf Stream, but as the journals of Ponce de Leon were not extant, the conclusions in regard to that marine feature are doubtless such as occurrrd to Herrera a century after the time of Ponce de Leon. He probably drew a chart showing the contour of the Florida peninsula, and it seems likely that the sketch given by Diego Ribero, in the year 1529, was reduced from the charts of Ponce. In the year 1513 Ponce de Leon went to Spain to make report, but nothing can be found of any detailed statement; merely the sentence "to the northwest end of Cuba has appeared a great country, which they believe to be a continent."

VELASQUEZ, 1511-'14.

Shortly after the time of Ponce de Leon the gulf shore of Cuba was settled by Spaniards. In the year 1511 Don Diego Colon, then Governor-General of the West Indies, resolved upon the conquest of the great island, of which nothing was known to Europeans except that it was a good

land, thickly inhabited, and rich in natural productions. The governor sent out Captain Diego Velasquez with three hundred men in four vessels. That commander was soon followed by adventurers from Jamaica, Porto Rico, and other West Indian islands, and amongst them was Sebastian de Ocampo, who had passed around the island in the year 1508. Pamphila de Narvaez arrived in 1514, and marched partly on shore. He was very active, and twelve years later was killed in Florida. Both Velasquez and Narvaez had been told of the existence of some Spaniards in the neighborhood of Havana. These had been shipwrecked a few years before, and with a view to their liberation Father Las Casas hastened to that region.

When Velasquez had traversed and taken possession of the gulf shore of the Island of Cuba, he founded, in 1514, near Ocampo's landing place, the town of Havana, and in the same year sent his captain, Narvaez, to the west end of the island, now known as Cape San Antonio. At intervening places Spanish settlers built houses and improved the land, and this was the first firm foothold which the Spaniards gained on the shores of the gulf. The settlement on the north coast of Cuba was the foundation of future conquests and explorations.

DIEGO MIRUELO, 1516.

It is probable that the Spaniards, settled by Velasquez near Havana, built vessels as well as houses, and it seems likely that they made visits into the Gulf of Florida, and perhaps to the Florida Keys. There was certainly a trading expedition from Havana in the year 1517, conducted by Pedro d'Avila, and records show that mariners and coasting and fishing vessels were known in the port of Cuba in the year 1518. Barcia states that Diego Miruelo went from Cuba to Florida in the year 1516, and there traded with the Indians.

CORDOVA.

Francisco Hernandez de Cordova was a wealthy settler of Cuba, who held Indians and also an estate near the town of Espiritu Santo, near the middle of Cuba. He was elected as commander-in-chief by upwards of a hundred enterprising young Spaniards, who desired to make discoveries. All of them had come to Cuba from Darien, where the Governor, Pedro Arias de Avila, had not found sufficient occupation for them. But in Cuba they were too late. Velasquez had already completed the conquest and partition of the island. Cordova, however, accepted the offer of these men who wished to gain wealth or reputation. He fitted out two vessels, and the third was given by the Governor under the condition that they should bring to him a number of Indian slaves from the islands of the Guanajos. The offer was declined by Cordova, who explained that they were concerned only in exploration and discovery. Velasquez then gave them the ship on their own conditions. Their chief pilot was Antonio de Alaminos, and the vessel sailed on the 8th of February, in the year 1517, from Havana. Going westward the party doubled Cape San Antonio after coasting twelve days, and then stretched into the sea westward, without knowledge of rocks, shoals, currents, or winds that might be encountered. It is not mentioned that they had on board a copy of the chart of Columbus made in 1502, nor of Solis and Pinzon's chart of 1506. The only inducement to take a western direction seems to have turned on the recollections of their chief pilot, Alaminos, who remembered that Columbus, with whom he had sailed as a boy, had always a strong inclination to go westward. After a heavy storm, which lasted two days and nights, the course was changed, and twenty-one days after their departure from Cuba they came in sight of land. From the ship, they saw a large Indian town, and when they came to anchor, on the 4th of March, many canoes came out to them, and some were of size sufficient to contain fifty Indians. These, in their intercourse with the Spaniards, frequently repeated the words "Con escotoch"! and hence on the chart the place was marked "Punta de Cotoche." The Indian words were probably intended to express an invitation to come ashore.

After a short land excursion to the interior, the Spaniards had a bloody encounter with the Indians, but at the same time found to their great joy good buildings and temples, and in them idols and ornaments of gold. Thus stimulated, they held along the shore to the west, and discovered points, bays, and many of the shoals and reefs of that part of Yucatan. The pilot, Alaminos, however, believed that the newly-found country was an island, a suggestion as will be

remembered, made by Ponce de Leon in regard to the peninsula of Florida. On the 25th of March they reached a bay, which the Indians called "Quimpech," but in the Spanish pronunciation it is known to this day as Campeche. The natives hailed the adventurers repeatedly with the word "Castilan," at the same time pointing toward the east. While taking in water from shore the Spaniards saw temples ornamented like those at Catoche, but these could not be examined, as the natives collected in great numbers and marched in battle array. The Spaniards retreated, but brought off their water casks, and after stowing them sailed away to the southwest without interruption, favored during six days by wind and weather. On the seventh day a heavy north wind caused the casks to leak, and made it needful to seek another anchorage. They consequently went into the mouth of a river near an Indian village, the name of which was Pononchau. Here they found water wells, buildings of stone, maize plantations, and other signs of a good state of cultivation; but trusting too far inland they were attacked by natives in overwhelming numbers, and like those of Campeche, the Indians uttered the cry, "Castilan," "Castilan." In cutting their way through the mass of savages the Spaniards lost fifty-seven men in killed and two others were carried away as prisoners. The boats were capsized, the water casks lost, and all who reached the ships were marked by wounds. The commander, Cordova, was wounded in twelve places. This sad event ended further progress, and the place was named by the pilot and mariners of the expedition "Bahia de la mala pelea," *i. e.*, Bay of the disastrous fight. It was probably the mouth of the river now known as the Champoton.

The lessened force being insufficient to work three ships, one of the vessels was burnt, and the party resolved to return to Cuba. They suffered for want of fresh water, and consulted the charts. Alaminos judged it best to leave the direct course and by turning northward to make the coast of Florida, and then fall back to find the harbor of Havana. Only this general fact is known. That commander had, when with Ponce de Leon, crossed the Gulf of Florida twice, and he had sailed also with Ortubia amongst the Yucatan Islands. It is probable that, with Ocampo, he passed entirely around the coast of Cuba. Hence his opportunity was ample for making observations on the usual eastern direction of the winds which blow into and along the eastern gate of the Mexican Gulf. The vessels had a short time before suffered by a heavy northeast gale. The expedition was probably saved from further disaster by adopting the proposal of Alaminos. Going north and northeast the party came in sight of the coast of Florida. He landed with some men, and recognized the region which he had seen in 1512. By digging wells good water was found, but they were attacked by Indians while so employed. In passing to Havana (by the Florida Keys) they had only 4 fathoms of water, and the largest vessel struck against rocks, but the exhausted crews at last reached Havana. The wounded captain, Cordova, retired to his plantation near Santo Spiritu, and there died. Some of his officers and men presented themselves to the Governor (Velasquez) and reported favorably of the new country. Some of the products were shown, and two of the inhabitants who had been taken as prisoners.

GRIJALVA AND ALAMINOS, 1518.

Reports in regard to Yucatan led to the fitting out of four ships, which were provided with a force of two hundred and twenty men. Juan de Grijalva, a cousin of the Governor, and a man of energy and prudence, was at the head of the fleet as Captain-General. Pedro de Alvarado, Francisco de Montejo, and Alonzo de Avila, all of whom afterwards became famous as companions of Cortes, were assigned to the command of vessels; and some of the soldiers and sailors who had been with Cordova joined the expedition. Amongst others was the chief pilot, Antonio de Alaminos, and Bernal Diaz del Castilla.

The instructions given by Velasquez to the commander of this expedition are not extant, but in the instructions of the same Velasquez, addressed to Cortes in the year 1518, the Governor says that he sent out Grijalva principally for the purpose "of examining and circumnavigating the island of Yucatan and to discover further onward."

The harbor of Matanzas, on the coast of Cuba, was indicated as the general rendezvous for officers, men, and ships, and from that place the fleet sailed on the 5th of April, 1518. Following the track of Cordova's expedition, Cape San Antonio was sighted in eight days, and from thence,

after sailing ten days, they reached the coast of Yucatan. By the currents they were carried southward and first saw the island of Cozumel, to the south of Cape Catoche, on the 3d of May. To Cozumel was then given the name "Isla de Santa Cruz." They followed the track of Cordova to Champoton, and there had a fierce battle, but the savages of Yucatan were put to flight. Coasting farther they soon saw an opening which was considered to be the mouth of a large river, but, on entering, it was found to be a large lagoon. As late as the year 1550 charts were drawn on the authority of Alaminos that show Yucatan as an island; and this was long after the pilots and men of Grijalva had found out their mistake.

From the lagoon last mentioned the party sailed very cautiously along the unknown coast, moving only by daylight. On the 7th of June they saw the mouth of a great river, which was entered by the two smaller vessels and by all the boats. The two larger vessels remained at anchor outside. Here the Indians assembled in thousands, but there was no hostile demonstration. Presents were interchanged. Amongst the Indians were some trinkets of gold; and the occasion was further remarkable, as then for the first time the name "Mexico" was pronounced in the hearing of Spaniards. When the natives were asked where such gold could be found they pointed towards the rising sun and pronounced the name "Mexico." The Spaniards quickly embarked for the search, but the river, which they named Rio Grijalva, was long after his time known as Rio Tabasco, as bearing the name of the cacique of the region.

An active period followed in which river mouths and other entrances were first known to Europeans. The Rio de las Banderas became famous because Spaniards there found subjects of the Indian Emperor Montezuma, and possessed themselves of a considerable quantity of golden curiosities. In exchange for a few cheap European trinkets and blue beads they gained the sum of 15,000 pesos. The next place visited was that which became the renowned port of Juan de Ulloa. This came into view on the 18th of June, and there some poor Indians had been sacrificed to the pagan deities. Hence the place was named Isla de Sacrificios. The island and its name stands on every old chart of the Mexican Gulf. At another place on the beach the Spaniards built huts and remained several days exploring the vicinity. On a neighboring island evidences appeared of the sacrifice of human beings. These were viewed by Grijalva with horror, and by an interpreter he asked what had caused these abominations. The answer was, "Olua"! "Olua"! Hence the name of the place was marked on the chart as "Ulloa." This happened on the day of St. John, and therefore addition was made to the Indian appellation; the place was known as San Juan de Ulloa. The region adjoining was named Saint Mary of the Snow. Grijalva resolved to send a message to Velasquez by Pedro de Alvarado in the ship San Sebastian; and moreover his party needed provisions. All the gold then gathered was sent, and also written reports from the several officers. After Alvarado's departure (on the 24th of June) Grijalva and his men started with the remaining vessels and passed along the coast in hope of further discoveries. With the mountains of Mexico constantly in view, they at last came to a river, "Rio de Canoas," in the province of Panuco. Many Indian canoes made out boldly and commenced battle, but with little effect, against the Spanish ships. Proceeding farther, a great cape was seen, but could not be passed, as the currents were strong. The pilot, Alaminos, advised against sailing farther to the north. It was found, moreover, that provisions were scarce, and that some of the ships leaked badly. As winter was approaching the commander decided to return to Cuba. On the 29th of September that island was sighted, and on the 9th of October they entered the port of Matanzas, from which they had sailed six months earlier. On the resulting charts an important part of the gulf was represented, and on them appear the names "Mexico," "New Spain," "Terminos," "Ulloa," and numerous other designations that are yet retained.

From Ulloa a vessel was sent by Grijalva under command of Pedro Alvarado with orders to examine the coast of Cuba. The vessel arrived in safety, but no details are known respecting the observations then made. So also of the voyage of Christoval de Olid, whom Velasquez sent from Cuba to follow the track of Cordova and Grijalva. Olid reached the shores of Yucatan, but by heavy gales was forced to return without meeting Grijalva or seeing much of the hitherto unknown coast. Olid was subsequently sent by Cortes to Yucatan and the Bay of Honduras.

On his arrival at Cuba, Grijalva found that much interest had been excited by the discoveries of Alvarado. The Governor, Velasquez, had fitted out another armament, and, although Grijalva

had been energetic, the governor was not content, as that commander had not settled and fortified a place in the new country which was supposed to be rich. The commander was not again employed, and soon after went to Jamaica, entered into the service of Garay, and accompanied him in his expedition to Panuco in 1523. Grijalva was killed in a revolt of the Indians in Nicaragua, where he had joined the standard of Pedriarias.

FERNANDO CORTES, 1519.

The voyages and operations of Cortes are described in the letter which he addressed to the King of Spain from Vera Cruz early in August, 1519. The letter is not extant, but fortunately the chaplain, Gomara, gives an extract in the fortieth chapter of his Cronica de la Nueva España; and there are other sources of information touching the adventure. Velasquez instructed Cortes to go first to Cozumel Island, and from thence to Yucatan. He was to sound and examine all the ports, inlets, and watering places, including those of Mexico, and afterwards give a complete nautical account. But the names "Mexico" and "New Spain" are not mentioned in that document.

The armament consisted of eleven vessels, which carried five hundred soldiers and officers, and the account says more than a hundred pilots and sailors. Nearly all the vessels of Grijalva and his principal officers accompanied, but the commander was excluded. As in the preceding expeditions, Antonio Alaminos went as chief pilot. Morillo, an Indian captured by Grijalva at the promontory of Catoche, and who had been baptized and taught Spanish, was the interpreter for Yucatan. Havana was the place of rendezvous. Pedro de Alvarado was sent in advance, and the other vessels sailed from Havana on the 10th of February, 1519, and had a short passage to Yucatan and the island of Cozumel. There Cortes questioned the men of Grijalva respecting the word "*Castilan*" which the Indians of Yucatan had so often pronounced, and he concluded that some Spaniards were in the vicinity. On further inquiry these proved to be men who survived the shipwreck of Hieronimo de Aguilar.

On the 5th of March the fleet doubled Cape Catoche, and soon after a vessel commanded by Escobar was sent to examine the Bay of Terminos and select a site for establishing a colony. Doubtless his report was unfavorable, as when he rejoined the fleet Cortes sailed immediately for the Tabasco River, and reached the entrance in seven days. It is thus made plain that no soundings were recorded, nor nautical examinations of any other kind. His intention was to settle and fortify. Some severe battles occurred with the Indians of Tabasco River. He accepted their peace offerings and again listened to stories of the country "Mexico." On Holy Thursday the fleet came to anchor at San Juan de Ulloa, and there some Indian messengers approached in canoes and told Cortes of the great sovereign of the interior, Montezuma. Two vessels were prepared and sent northward under command of Francisco de Montejo. These were piloted by Alaminos. The vessels followed the track of Grijalva, but went beyond his limit, which was Cape Roxo. Montejo and Alaminos doubled that cape and discovered the Rio Grande de Panuco, at the mouth of which they arrived only a few days earlier than another Spanish navigator who had reached that quarter from the north. Strong contrary currents withstood Montejo and Alaminos, and a heavy "norther" threatened them with destruction. But the north wind forced them back to Ulloa, after an absence of twelve days. The only anchorage which Alaminos deemed safe against strong north winds was some distance to the northward of Ulloa, and to that place the army was transferred and the colony was founded. Cortes named it Villa Rica de la Vera Cruz, *i. e.*, the rich town of the true cross. The latter designation implied that they had landed on Holy Friday; and the word "rica" was added because gold was obtained. The name has import similar to that of the "Golden Gate," as applied to the entrance of San Francisco Bay.

Cortes fortified the place and dispatched to the King of Spain a vessel with presents and reports of his operations. He then destroyed his fleet and marched early in August, 1519, for the conquest of Mexico.

Cortes confided his dispatches and presents to Puerto Carnero and Montejo, two of his officers, and placed them on a vessel, of which Antonio Alaminos was chief pilot. Bernal Diaz says that the best sailing vessel of the squadron was chosen. Hence it was probably the "S. Sebastian,"

which vessel is repeatedly designated as the best sailer of the squadron of Cortes. Under command of Alvarado that vessel had often sailed as a pioneer in advance of squadrons. Cortes conferred with Alaminos respecting the most direct route from the Gulf coast towards Europe, as no navigator had previously aimed at lessening the line of navigation. Only one vessel had been sent directly over, and that carried intelligence of Grijalva's success, but the passage was made through the Windward Islands.

Alaminos, who had been with Ponce de Leon in the year 1512, and with Cordova in 1517, proposed to sail between Florida and Cuba, to the east and north. Cortes adopted the plan, and his messengers, under the command of Alaminos, sailed from Vera Cruz on the 26th of July, 1519; crossed the Gulf of Mexico, and passing eastward entered the Strait of Florida; and the vessel which carried him arrived at San Lucar, in Spain, early in October. It would be needless to speculate on the route taken, and whether or not the Gulf Stream favored the passage. We know, however, with certainty that in going directly eastward he came in sight of the Azores, and no navigator is on record for the same latitude previous to the year 1519. To Alaminos is doubtless due the advantage of passing from the West Indies to Europe by keeping in the Gulf Stream. The Bermudas were soon after discovered and a plan for their settlement was fixed in the year 1527.

Alaminos never returned to the Gulf shores. He went to Spain with the father of Fernando Cortes, and reported his own discoveries and those of Cortes, Grijalva, and Cordova. He was certainly the most intelligent and energetic of the Mexican Gulf pilots. He was with Columbus in 1502-'03 in the waters of the West Indies and towards Yucatan. With Ponce de Leon he passed around Florida and the Lucayan Islands in the year 1512, and in the same year was with Ortubia on the voyage to Bimini. He accompanied Cordova to Yucatan in 1517, and in the following year went with Grijalva to New Spain. In the year 1519 he attended Cortes along the west shore of the Gulf as far as Ulloa; and in the same year went with Montijo as far as the river Panuco. His expedient in navigating to advantage by way of the Gulf Stream is commended by Humboldt. All the expeditions of this period, though conducted by others, may, so far as maritime history is concerned, be regarded as prompted by Alaminos.

DON ALONZO ALVAREZ PINEDA, 1519.

Francisco de Garay was a distinguished man who had been in the West Indies with Columbus, and to him had been committed the government of the island of Jamaica. Having become rich, he turned his attention to the north and west. When the reports of Cordova and Grijalva became known, the Governor of Jamaica believed himself entitled to a share. Garay possibly had some intercourse with the pilot Alaminos. The river Saint Peter and Saint Paul is not mentioned among the discoveries of Grijalva, but on many old charts it is marked as about midway between the river Panuco and Vera Cruz, and always to the south of Cabo Roxo. It seems that Alaminos regarded this as the limit of Grijalva's discoveries. Garay therefore fitted out four vessels while Velasquez was preparing his armament for Cortes. The command was given to Don Alonzo Alvarez Pineda, who sailed from Jamaica to the northwest early in the year 1519; probably about the time when Cortes sailed from Havana. Pineda, following the sailing directions of Alaminos, sailed from Jamaica early in the year, and coasted along the west side of Florida Peninsula in hope of finding some passage. Finding none, he held on westward and entered the river Panuco, where Montejo had been a few months earlier. He next visited the harbor at which Cortes had built his fortress of Villa Rica de la Vera Cruz, and from which Cortes had only a few days previous departed with his army for the conquest of Mexico. The ships of Pineda were destroyed by the forces of Cortes stationed at Villa Rica. That commander was absent at an Indian town some leagues away, but he hastened to the coast, and captured some of Pineda's men who had landed. From these he learned that the vessels had been sent by Garay, the Governor of Jamaica, and that they came from the north, where they had traversed more than three hundred leagues of the coast; and proposed arrangements in regard to the limits of their respective discoveries and governments. But Cortes declared that the river Panuco and all the countries of that region had been already taken in possession by himself in the King's name. So he held Pineda's men and enlisted them in his own army. He was not successful in an attempt to get possession of Pineda's

little fleet. The capture of the men must have been early in August of the year 1519. Cortes was about that time at Zempoala, and on his march to Mexico. Pineda remained forty days at the mouth of the river Panuco.

Pineda sent home with his report a chart of the Gulf of Mexico; and by Garay's messengers it was presented to the King of Spain. On that map are represented Florida, Cuba, and Yucatan, but the outlines were probably given by Alaminos, and to these were doubtless added the northern discoveries of Pineda.

There is another chart of the Gulf published in the year 1524 at Nurnberg, to accompany the second letter of Cortes, the date of which is October 30, 1520. This resembles the chart published by Navarrete, but is marked with more names. Cortes, in the second letter, does not refer to this sketch, but he relates particulars in regard to the capture of Pineda's men. It seems probable that we owe to Pineda all early knowledge concerning the northern part of the Gulf of Mexico. On the first charts the mouth of the Mississippi is indicated, with the name *Rio del Espiritu Santo*, and it was so designated by Spaniards for more than a century. To the east of it is marked on the early chart a bay, called "Mar Pequēna" (*i. e.*, Little Sea), and this is doubtless Chandeleur Bay. Of many names not now known on charts perhaps "Cabo Bravo" is an exception, as it marks the position of the Rio Bravo of our day, and perhaps gave origin to that name. Most of the designations were given by Pineda and the pilots of his four ships.

NARVAEZ, 1520.

The proceedings of Cortes in New Spain were regarded by Velasquez as rebellious. He therefore sent a large armament under command of Pamfilo de Narvaez, who had assisted him in the conquest of Cuba, and that commander was instructed to bring Cortes to obedience, and to complete the conquest of Mexico in the interest of Velasquez.

Narvaez sailed from Cuba early in March, 1520, with eighteen vessels, which carried nearly a thousand men as soldiers, sailors, and pilots. On the 23d of April he was at anchor off San Juan de Ulloa. Such developments as he may have made in geography are not known. His military undertaking ended in disaster. Made prisoner by Cortes, the men of Narvaez joined the banner of the conqueror. He was, however, energetic and subsequently acted on another part of the Gulf coast.

PINEDA AND CAMARGO, 1520.

Francisco de Garay, Governor of Jamaica, sent a second expedition into the Gulf in the spring of the year 1520. His men, under Pineda, found nothing attractive on the north shore of the Gulf; but near the river Panuco they saw the fine region now known as the province of Tamaulipas. There the natives had some gold. Pineda apparently did not know that he had been anticipated by Montejo and Alaminos; nor was Garay aware of the earlier advance of Cortes to the Rio Panuco. That commander, with the co-operation of Montezuma, had sent messengers to Panuco and obtained tribute in token of the submission of the Indian chiefs.

Garay committed the enterprise to Alonzo Alvarez Pineda, and as second in command Diego Camargo, and gave them three vessels, one hundred and fifty men, and the materials requisite for building a town and fortification. At Panuco, a settlement was begun, but probably at the investigation of Cortes the Indians attacked the settlers. In the constrained embarkation one of the vessels was wrecked. Pineda was killed. The remaining vessels under Camargo sailed south, and at Vera Cruz the soldiers went into service with Cortes. Garay had previously despatched two other vessels with troops to the river Panuco to aid in founding the colony; but, hearing of the disaster to Pineda, they went into the harbor of Villa Rica, and they also joined the army of Cortes.

PONCE DE LEON, 1521.

SECOND EXPEDITION.

When the fame of Cortes became great (says Herrera), the spirit of other adventurers was aroused. All desired to undertake something for reputation. There was a general move-

ment toward the northwest, and the earliest discoverer of Florida was affected like others of great energy. After his first expedition of 1512 he passed two years in Spain, and the King had conferred on him the title of "*Adelantado de la isla de Bimini y la Florida*," and the government of that province. But he was soon afterwards engaged in operating against the Indians of the Caribbean Islands, and subsequently lived in retirement at Porto Rico. In the year 1521 he fitted out two vessels and sailed to Florida. It is only known that he landed there after a boisterous voyage, probably on the western coast of the peninsula. He had a severe battle with the natives and many of his men were killed. Ponce de Leon himself was mortally wounded. He died of the hurt on the coast of Cuba. One of his vessels (Herrera says) went to Vera Cruz, and there Cortes bought her munitions and stores. After his death the title of Adelantado of Bimini and Florida was conferred on his son, Don Luis Ponce de Leon, but his name is not connected with any discovery or geographical development.

FRANCISCO DE GARAI, 1823.

Of two expeditions sent to the Gulf by Garai, the second ended in total loss. But regarding his large outlay, the King issued a decree granting him the government of the province of Arnichel with such rights as were then usual. But no mention was made of the limits nor of the boundary line of the province. Christoval de Tapia was to be sent out as a special commissioner to confer in what related to Cortes, but he returned to Spain in 1522 and had not settled anything. Cortes went forward with vigor in plans for conquest. He marched with an army from Mexico to Panuco and founded at the mouth of the river a colony called "*San Estevan del Puerto*."

Garai meanwhile was preparing an armament for the same region. He fitted out eleven vessels and an army of nearly 1,000 men, and thus exhausted his own private means. The pilot of the fleet was Diego Miruelo, a nephew of the Diego Miruelo who was in service with Ponce de Leon. After a delay of two years the fleet sailed on the 26th of June, 1524. What Cortes had done was made known at a harbor in Cuba where the fleet touched, but the vessels nevertheless kept on, and reached the shore of Mexico near the mouth of the Rio de las Palmas. On all old Spanish charts that river is marked as at some distance to the north of Panuco; sometimes on the 25th and sometimes on the 24th parallel. The river is marked on a chart of 1520, which doubtless Cortes copied from Pineda's chart. It is the river now known as the *Santander*.

Garai sent a vessel into the river and it was explored to a distance of 15 leagues. Then his fleet was sent under command of Juan Le Grijalva to sail southward while he marched with the army in the same direction. At Panuco it was his intention to found a city to be named "*Garayana;*" but the march was through a desert. The army arrived in distress on the borders of Mexico, and the soldiers of Cortes were neither provided nor inclined to receive so many guests. Foraging parties were sent out. Of the fleet, six vessels were lost and the others were damaged. Only a short time before the arrival of Garai the royal decree was received in which Garai was peremptorily forbidden to land at Panuco, as that province was regarded as belonging to Mexico. Cortes promptly sent a copy and Garai recognized that he had erred. He resolved to retire with his fleet and army to the north and make a settlement at the Rio de Palmas. Orders were given to that effect, but his soldiers were reluctant and declared an inclination to stay where they were.

Garai concluded to join Cortes. He went to Mexico and was well received, but broken-hearted and poor he died soon after his arrival in the house occupied by Cortes. He made that commander the executor of his will; and one of his sons was betrothed to a natural daughter of Cortes.

After the death of Garai it may be said that the empire of Montezuma was wholly subject to Cortes, and he extended his views to more distant regions. He fitted out vessels on the coast of the Pacific Ocean, and also sent vessels to Central America, under Christoval de Olid. Another armament was destined for adventures on the northern shores. In his fourth letter to the Emperor Cortes remarks that "nothing seems to remain but to explore the coast lying between the river Panuco and Florida, the latter being the country discovered by the Adelantado Juan Ponce de Leon, and the northern coast of Florida as far as Baccalaos, because it is considered, certain that there is a strait which leads into the South Sea." The delusion continued, and twenty years after the time of Columbus many hoped to find a strait; if not between Florida and New Spain, it was thought that the strait might exist north of Florida.

Cortes had destined three caravels and two brigantines, and his direction was that they should advance as far north as the Baccalaos, *i. e.*, to Newfoundland. But soon after he was informed of the revolt of his captain, Olid, in Honduras, and felt obliged to march south. Moreover, disturbances in Mexico claimed attention in the year 1526 and 1527; and then the exploration and government had passed into other hands. By Cortes, more than any other adventurer, the Gulf of Mexico became known in Europe; and it was soon the center of flourishing commerce. But he made no general chart; and that fact is the more singular because he organized his plans for conquest by means of a sketch drawn at his request by Montezuma.

NARVAEZ, 1527-1536.

Don Luis Ponce de Leon, on whom the title of Governor of Florida had devolved from his father, remained inactive; and this seems to be true also of the son of Garai, to whom a daughter of Cortes had been betrothed. Cortes had promised protection, but the spirit of adventure found place only in Pamfilo de Narvaez, who had been previously engaged in explorations on the Gulf coast. He had been with Velasquez to Cuba; had carried a fleet to Mexico; and had been unfortunate in an expedition against Cortes, who took him prisoner, but, at the request of Garai, liberated him and gave him means to return to Cuba and to Spain. He was rich, and offered his services for the conquest of the north parts of the Gulf, and in the year 1526 made with the Government a treaty signifying that he should be allowed to assemble a naval and military force, and with it discover and possess all countries north of the Rio de las Palmas on the frontier of New Spain to Florida, and that he should found a settlement from one sea to the other, and report on all that was worthy of record. The commission was ample, as it comprised the settlement of our present Southern States, with a shore line of more than 1,200 nautical miles. If Narvaez had fulfilled his commission, Cortes would have been confronted by a powerful rival. At the same time a commission was given to Francisco Montejo as Governor of Yucatan, and to Pedro Alvarado as Governor of Guatemala. These may be regarded as intended to check the influence of Cortes. He had treated Narvaez generously after his defeat, but they could not be regarded as friends.

The government included in the boundaries was named "El Govierno del Rio de las Palmas," and it was expressly said that in this government should be included all that was called Florida. Narvaez was made Adelantado and Captain-General. Amongst other officers appointed by the King was the treasurer of the expedition, Cabeça de Vaca.

Narvaez sailed from San Lucas, in Spain, on the 17th of June, 1527, with five vessels and six hundred men. After crossing the Atlantic he touched at Saint Domingo, and there one hundred and fifty of his men escaped. Near Cuba the fleet suffered by a hurricane, but at that island he passed the winter. With the assistance of one of the most wealthy and generous of the proprietors (Varco Porcallo), he collected there a store of provisions and engaged other ships and men, and also the chief pilot, Diego Miruelo, who deserves particular mention, as he had accompanied Garai on his expedition to Rio de las Palmas. He was, moreover, a nephew of the Diego Miruelo who was with Ponce de Leon and afterwards with Lucas de Ayllon. Cabeça de Vaca and Herrera record him as an experienced pilot of the Rio de las Palmas and of the north coast, but it seems unlikely that Miruelo could gain much experience with Garai in the year 1523. More probably he was with Pineda, in the year 1519, around the north line of the Gulf coast.

In March, 1528, Narvaez sailed from the south coast of Cuba, doubled Cape San Antonio in bad weather, and sailed towards Havana, but because of very stormy weather he was unable to enter that port. He was near the coast of Florida early in April, and on the 13th of that month anchored in a bay, which was found to be extensive. This was doubtless Tampa Bay. In the huts of the Indians who lived on the shore were found such boxes as the Spanish merchants then used for their goods; and they were likely the remains of some wreck. Pieces of cloth were also found like the stuff used in New Spain. The natives said that these articles were from "Apalache," and that such goods were plenty there, as also gold. That place was sought, and it seemed best to send the soldiers and horses to go on land while the fleet kept near the shore to find a harbor. The army moved on the 1st of May, leaving the fleet under command of Carvallo, with direction to

anchor at some safe place. In case of delay the vessels were to sail to Cuba and bring provisions to the Bay of Santa Cruz, where all the forces were to join. It has been well made out that the bay last mentioned is what is now known as Tampa Bay.

With about three hundred men Narvaez marched during a fortnight to the north and reached a great river. One day was spent in passing it, with such labor that the forces rested for several days. Two exploring parties went by the coast to look for a harbor. They found a shallow bay, and it was probably the water at Cedar Keys. The river was doubtless the Withlacoochee, or the Suwanee. The party saw nothing of the coast again, but kept on in search of "Apalache," and came in sight of a village on the 24th of June. They took possession and found some maize, but nothing else of consequence. On the 27th of July they reached Ante, and saw many bays, but the Gulf coast was not in view. One-third of the army had died or was sick, and the horses which carried the sick were exhausted. The ships were not in sight and means of subsistence could be had only by battles with the natives. On the 22d of September, after having eaten the last of their horses, the party embarked in four wretched barges, and moved westward along the shore of a bay which they named Baia de los Caballos, *i. e.*, Bay of the horses. This was no doubt the expanse now known as Saint George's Sound. Near Saint Mark's De Soto found the remains of the forge used by Narvaez, and also some skulls of horses.

The party of Narvaez kept on westward, following the bay shores and inlets, and on the 29th of September came to an island near the shore (Saint Vincent's Island), and passed a strait which they named Saint Miguel. This corresponds with what is known now as Indian Pass. Keeping on westward for thirty days they probably were in the vicinity of Mobile Bay about the end of October. Then an island is mentioned where they remained six days, and soon after a bay, which was full of islands. This was perhaps Chandeleur Bay. Soon they took fresh water from the sea, and it may be supposed that they were then at the delta of the Mississippi. By the current they were forced away, and a heavy norther carried them into the Gulf. Two of the boats foundered, but the one which carried Narvaez remained and was at anchor when a sudden flaw of wind occurred. There was on board besides the Governor only two sick men, and neither provisions nor water. They were never seen again, and thus perished in November, 1527. The shore party endured great distress, but nearly all perished from hunger and fatigue. Soto Major was one of the only two survivors, but he died, leaving Esquivel, who wandered in search of subsistence. To another of the shipwrecked Spaniards he told of the fate of Narvaez, and then disappeared. Figueroa subsequently met Cabeça de Vaca and to him recounted the misfortune.

Before Narvaez set out from Tampa Bay to the interior, the pilot, Miruelo, was sent, as already stated, to look for a harbor; but three of the ships were left at Tampa, under Carvallo, with instructions to go up along the coast and to join the other vessels. Miruelo, not finding his supposed harbor, turned back in accordance with his instructions and sailed to Cuba, and from thence dispatched a vessel with provisions to Tampa Bay. Carvallo, with the remaining three ships and a hundred men, sailed north, but finding no harbor turned back and joined Miruelo at Tampa Bay. Their search for Narvaez seems to have employed nearly a year, and as it was fruitless they sailed to New Spain. The old charts are marked with the name "Miruelo Bay" in the place occupied in our maps by the name Apalache Bay.

Cabeça de Vaca, after being separated from Narvaez by currents and storms early in November, 1527, probably near the Mississippi delta, was, after rowing some days in the boats, at an island where some shipwrecked Spaniards were assembled. There they wintered, and it was very likely on one of the islands of Mississippi Sound. Four of the Spaniards started westward in search of Panuco. Their names are given in the narrative, but nothing else is known concerning their fate. Some preferred to remain with Cabeça de Vaca on the island Malhado, and there were survivors six years later. They sustained themselves by fishing and hunting, and were constrained to work for the Indians, who treated them as slaves. Finally, in the year 1533, the two Spaniards resolved to leave the region by going westward. On the west side of the Mississippi Lope de Oviedo separated from Cabeça de Vaca and was not heard of again. But the adventurer last named found three other Christians who were held as slaves by the natives. These were Andreas de Dorantes, Alonzo de Castillo, and Estavanico, a black servant. They associated, escaped, and started westward, and in the course of two years reached a Spanish settlement near the Gulf of

California. Soon they were conducted to Mexico, and there the Viceroy Mendoza and Cortes received them with kindness. Of the names added to charts of that period only the name Apalache remains. The geographical results became known in time. Miruelo and Carvallo returned in 1528; but Cabeça de Vaca was absent from Europe until the year 1536, and his observations were not published until the year 1555, when they were issued in Valladolid.

Cabeça de Vaca was willing to return if the Emperor would confer on him the government of the regions through which he had journeyed, but Don Fernando de Soto appeared at the same time in Spain. He had been in service with Pizarro and had acquired wealth. He lent money to the Emperor, lived in comparative splendor, and added to his influence by marriage with a lady who belonged to one of the most influential families of Spain. His ambition stirred at the mention of vast regions, traversed by Cabeça de Vaca, and he requested of the Emperor a commission, and was made Adelantado of Florida. The government of Cuba was at the same time conferred upon him, as the port of Havana was best suited for fitting out vessels for any purpose.

De Soto used his own means largely in fitting out the armament, and besides he had assistance from wealthy young noblemen of his acquaintance. Even from Portugal a number of cavaliers offered their services. The armament sailed from San Lucas in Spain in April, 1538, with a force of upwards of six hundred officers and men, and after being two months at sea reached the coast of Cuba at Santiago. After settling the details of government he marched to Havana, while the fleet, passing around Cape San Autonio, made for the same port, and there the entire force was assembled at the end of summer.

Somewhat earlier, Havana had been plundered and burnt by French pirates. De Soto rebuilt the churches, and fortified the place against another attack. He was thus occupied during the autumn and winter of 1538–'39. It is not known that he derived any advantage from the exploration made by Miruelo and Cavallo, the pilots of Narvaez, nor is anything known of the further career of those two mariners. They are not mentioned as being with the party of De Soto, but it seems very probable that he had in his command some of the explorers and pilots who had been in Florida. He had a certain Juan de Añasco, who had repute as mariner, cosmographer, and astrologer, and Añasco was sent in the autumn of the year 1538 with two small vessels to coast along Florida and note the ports, inlets, and bays. He went out probably in September, and two months afterward was again at Havana. Not satisfied with the results, De Soto sent him back with instructions to explore the coast with accuracy. Three months later Añasco brought information concerning a convenient harbor, but there is neither chart nor ship journal as the result of this voyage.

DE SOTO, 1539.

De Soto sailed from Cuba on the 18th of May, 1539, with a fleet of five large ships and two smaller vessels. He had a force of about seven hundred cavaliers, soldiers, and sailors. The largest ship had once carried the flag of the Admiral Don Pedro de Mendoza to the river La Plata. She had also been on a voyage to Mexico.

The fleet sailed directly to the port described by Juan de Añasco and arrived on the 25th of May, at the harbor where Narvaez had landed; *i. e.*, Tampa Bay. There he pitched a camp and made short visits from it to the interior to gain information from the natives. A Spaniard was found amongst them, Juan Ortiz, who had been with Narvaez and Miruelo. By the Indians he had been held eleven years. As he could converse in one of the Indian dialects of Florida he was able to serve as an interpreter.

De Soto sent his large vessels to Havana and stationed at Tampa only three small brigantines with some soldiers and horsemen. These were for service under Captain Pedro Calderon. De Soto set out for the interior with his principal force early in June. He marched first in a northeastern direction, and then (like Narvaez) having received some promising reports in regard to the country "Apalache," he went north and northwest; and passed several rivers, one of which was very probably the Suwannee. Of other rivers named at the period, none can be identified except the Ocilla.

After marching four months De Soto reached Apalache, on the 27th of October. The narrative

mentions nothing of vestiges of Narvaez, but several excursions were made to the north and to the east and west. Juan de Añasco went southward and found the village of Ante which is mentioned in the narrative of the Narvaez expedition. On the Gulf coast he found also the forge used by the workmen of Narvaez, the skulls of horses, and some other vestiges of the encampment. The Indian guides related particulars of the former disaster. Añasco sounded the bay of Ante, which is now known as Apalachee Bay. This service was of consequence to De Soto, and he decided to move his army and vessels up from Tampa Bay. Juan de Añasco was sent with thirty strong horsemen, and traveling near the shore he passed many swamps and river entrances. In ten days' travel he reached Tampa Bay and there found Calderon with the vessels. One of the ships was sent to Cuba with letters and dispatches to the wife of De Soto, and festivals were made to celebrate the success of the conquest of Florida.

The two remaining vessels were refitted and sailed under the command of Añasco towards Apalachee Bay, where they arrived on the 28th of December. These were no doubt the first European vessels that entered there. Meanwhile Pedro Calderon and the army set out from Tampa Bay and marched along the shore. They reached Apalache after the arrival of Añasco in Ante, *i. e.*, on the 3d of June, 1540. We know nothing of their observations, but Garcilasso de la Vega describes their sufferings and battles with the Indians. No mention of latitude is made in his narrative, and seldom is any geographical particular referred to.

DIEGO MALDONADO, 1540.

De Soto intended to make an expedition to the north from Apalache, and wished also to examine the country westward. He therefore dispatched the vessels under Maldonado to look into the bays, rivers, and ports in this section of the coast, but with instructions to return to Ante in two months. Maldonado sailed early in January, 1540, returned at the time appointed, and reported that he had found an excellent harbor 60 leagues from the Bay of Ante. From the description given there can hardly remain a doubt that the place mentioned was Pensacola Bay, and Maldonado was the first European that entered. This he did doubtless in the middle of February. Under orders from De Soto, a report was made by Maldonado and taken to Havana, in hope that settlers from Cuba might be induced to move. To such end Maldonado was ordered to provide facilities; to build vessels; take settlers, horses, seeds, &c., provisions, clothing, and ammunition. He was to return to Achusi in October, and was specially directed to bring back Gomez Arias, whom De Soto wished to retain near him. He received also from Maldonado two Indians, who were to act as guides in travel, and very probably he had also a copy of the coast chart made by that navigator. He made a "full report," but no copy is extant.

On the 3d of March De Soto moved northward with his army from Apalache, and passed through the middle parts of Georgia and South Carolina. He had the mountains in view, but came in sight of the coast of the Gulf in the middle of October, 1540. Historians designate the place as "Mavila" or "Mauvila," and it is now called Mobile. Previously the Spanish maps showed only a few rivers, but many water courses were marked after the time of De Soto. Some of the names then attached can yet be recognized, as, for example, Coca (the River Coosaw) and Tascaluca (now Tuscaloosa).

Doubtless De Soto intended to join Maldonado at Pensacola; but he had a severe battle with the Indians at Mobile, and lost so much baggage that his soldiers were dispirited, as were also the officers, who deemed it best to return to Cuba. In order to check the tendency to retreat, De Soto gave orders for marching to the northwest.

After the discovery of Pensacola Bay Maldonado went to Havana, and there found many that were willing to assist in the support of De Soto. He was soon provided with means, but finding no Spaniards at Pensacola Bay, Maldonado and Gomez Arias sailed in different directions in hope that the army might be in view from the coast. On prominent places they left letters in trees and on rocks stating what was intended in the ensuing spring. But at the approach of winter they were constrained to return to Havana without any intelligence concerning De Soto. No settlement seems to have been attempted at Pensacola Bay.

De Soto had been informed by the natives that Spanish vessels had passed along the coast;

and was told also that Mavila, where he had a battle, was not far from Achusi. But for reasons of his own, he kept a northwest course and wintered (1540–'41) at an Indian village named "Chicaça." This is probably now represented by the word *Chikasaw.* So also the name given by Herrera and Vega as "Alibamo" is doubtless identical with what is now written *Alabama.* At Chicaça there was a contest with hostile Indians. Their village was burnt and also the Spanish camp, and in it were destroyed the baggage, some horses, and also pigs on which the Europeans relied for subsistence.

On the 25th of April, 1541, De Soto renewed his search for the gold region, going as before northwest. After many battles with savages he reached a place called *Chisca* on the bank of the great river which the Spaniards named Rio Grande. This was afterwards and is yet known as the *Mississippi.* The exact date of the discovery cannot be fixed, but it must have been an early day in the month of May of the year 1541. De Soto remained at the place thirty days (until the 4th of June) and constructed barges for crossing the river. It was found to have a strong current. The water was muddy; much floating timber was seen; and there were several kinds of fish. De Soto came in sight of the river probably near the mouth of the Arkansaw at Chickasaw Bluffs. He traced the river upwards to a place named Pacaha, but the latitude cannot be fixed. It may have been near the mouth of the Ohio. His party went westward of the river about 200 miles, and again approached the buffalo country of which he had heard previously. In the autumn he came back to a place named Autiam (probably the Wachita River) and there passed the winter of 1541–'42. He thought of returning to the gulf by the river course, but became sick and died on the 21st of May, 1542, on the bank of the river at a place called Guachoya, which was probably not far from the mouth of Red River. He was buried in the water of the great stream which had been discovered under his leadership.

Maldonado and Arias had gone, the one westward toward Mexico, the other to the vicinity of Newfoundland, but there is no circumstantial account of these expeditions.

After the death of De Soto, the Spanish explorers debated the question as to the expediency of following the course of the river or passing to the interior westward. Luis de Moscoso, on whom devolved the command of the army of De Soto, held a council, and it was decided that the land route should be followed. Some of them had seen the map of the country and judged that Mexico would be only about 400 leagues distant. The natives told of another body of Spaniards in the west of Florida, and these no doubt were part of the expedition of Vasquez de Coronado traveling near the heads of the Arkansas and Red Rivers. The Spanish navigator Cabrillo, while on the coast of California, seems to have been told by natives of the movements of Coronado.

Moscoso probably led his men to the interior about 150 leagues from Guachoya, and the course taken is repeatedly stated as being to the west. It probably inclined southward and passed into Texas. Amongst Indian names mentioned by Moscoso's historians is "Naguatex," probably the present *Nacogdoches.* The journey was closed at a great river named by the natives "Daycoa." It is probably now known as Brazos River.

The Indians of the region provided the Spaniards repeatedly with fresh buffalo meat and with buffalo skins, but neither Moscoso nor either of his men saw any of those animals alive, and, as the party advanced, the country appeared to be more desolate. Their principal food, maize, became very scarce in the Indian settlements. Nothing could be learned respecting Christian travelers, and they returned to the Mississippi Valley. There they found maize and decided to follow the river course. After many hardships they reached an Indian place at the end of November, 1542.

Maldonado and Arias set out again from Havana in the spring of the year 1542, when De Soto was on his death-bed, and their movements were seconded by Doña Isabella de Bobadilla, the mourning wife of De Soto. Seven months were passed in examining the shores, but the route taken is uncertain. In the autumn they returned to Havana without result, intending after winter to start again.

The place, "*Nilco,*" reached by Moscoso in November, 1542, was probably near the mouth of Red River, and there it was that De Soto died. Early in December they stopped at another place, called Aminoya, where provisions were more plentiful. In the course of the winter seven vessels or barges were so constructed that they might be used at sea or with oars in rivers. These were no doubt the first vessels built in the valley of the Mississippi. While the water was high the Spaniards were not molested, but when the freshet lessened the savages became troublesome. A young

Indian chief, Quiqualtanqui, raised a general conspiracy for the destruction of the foreign intruders. Moscoso held his course only by repeated contests with the savages.

The Spaniards started at Minoya on the 3d of July, 1543, and were followed by a fleet of hostile canoes, which kept always in sight. They had frequent encounters and a number of Spanish officers and noblemen were killed. The last battle was no doubt near the site of the city of New Orleans. There the Indians disappeared, and soon after the Spaniards noticed evidence of being near the sea. At the Delta they saw masses of drift timber, and landed for the repair of their vessels. Near the Gulf the depth in the channel which they followed was 40 fathoms.

Moscoso passed into the Gulf of Mexico on the 18th of July, but having no compass nor instrument for determining latitude, they did not venture far from land. Turning to the west, they kept the coast in sight and sought for the entrance of the Rio de las Palmas. In the course of fifty days they landed frequently to procure fresh water, avoid storms, and for the purpose of taking fish. Finally they saw palm leaves floating on the sea, and some mountains were then in view. These must have been the highlands of Tamaulipas. On the 10th of September, 1543, they landed at the mouth of the river Panuco. The ships had been separated, but they arrived in succession, bringing about three hundred fur-clad adventurers, who were received with great rejoicings.

In the spring of 1543 Maldonado and Arias again took the field in hope of finding traces of De Soto. Their route is not known, but it is certain that they arrived at Vera Cruz in the middle of October, and there they learned that Moscoso with three hundred men had reached Panuco and brought intelligence of the fate of De Soto. In sadness the two explorers returned to Cuba and informed the widow, Donna Isabella de Bobadilla, whom there is much reason for regarding as the promoter of the searching expeditions which have been related. More than three hundred of the force led by De Soto returned to civilization, and being widely dispersed, the information which they brought was soon known in Europe.

ANDRES DE OCAMPO, 1543.

Coronado returned along the channels of the Gila and Colorado Rivers, and through Sonora and along the Gulf of California; but some of his companions, and amongst them a Portuguese named Andres de Ocampo, remained somewhat longer in the North. The friars were killed by the Indians, but Ocampo escaped and found his way back to Mexico. Gomara says, "He passed from Quivera through the country of the Chichimecas and came out at Panuco." This journey was through the region now known as Texas. Towards the same region appear to have been directed the travels of the Franciscan monk Andres de Olmos. Of him Barcia relates that in the year 1544 Olmos came to Panuco, and from thence went as a missionary northward to the country of the "Chichimecas bravos, on the confines of Florida." He says that he traveled more than 400 leagues, and that he collected and baptized some Indians and settled them at Tamaulipas. Other travels were undertaken under the leadership of Julian de Samano and Pedro de Ahamada. These ascertained that the northern regions afforded good furs, and that some pearls had been found, but means could not be obtained in Spain for verifying the statements.

After the return of De Soto's men many schemes were proposed for the conquest of Florida. A Dominican friar, Luis Cancel de Barbastro, after missionary experience amongst the Indians, proposed to go to Florida. His plan was approved by the Emperor, and the Viceroy Mendoza was directed to fit out a vessel. The command was given to Captain Juan de Arana, and the ship sailed in the year 1549 from Vera Cruz to Havana, and from thence to the west coast of Florida. She touched the land on Ascension day in about 28° of latitude. The intention was to land at Tampa Bay, but missing that entrance the party landed at Apalachee. There the Indians who had withstood Narvaez and De Soto soon killed the missionaries, Fray Diego de Tolosa first and then Father Luis Cancel. Other missionaries, one of whom was Father Beteta, were willing to try their best on another part of the coast, but Captain Arava being short of provisions took the first favorable wind and arrived in Mexico on the 19th of July, 1549.

Beteta and his associates were willing to go to the place where Father Cancel perished, but their offer was not accepted. The particulars are worthy of note only as accounting for slow progress in geographical development along the coast of Florida.

The dangerous navigation of the Gulf of Florida was the occasion of several shipwrecks, and those who survived disaster at sea were generally killed by the Indians. Some held as prisoners were rescued by Spanish visitors, and made known their adventures afterwards in Europe. The first shipwreck of which some particulars are known, occurred in the year 1545. Doubtless the vessel was large, as two hundred of the persons on board were killed by the Indians. Some were reserved and held as slaves, and of these some were alive twenty years after their capture. One was liberated by the Spanish Governor, Don Pedro Menendez de Aviles, about the year 1566, and in the preceding year another was saved by the French commander Jean Ribaut.

In the year 1551 a ship was wrecked near Cape Florida. The vessel was Spanish, and was returning with gold from Peru, under Captain Juan Christoval. Among the passengers was a young man, Hernando Escalante de Fontaneda, who, "though the poorest of all, had with him 25,000 *pesos de oro*." Nothing is said of the fate of other passengers, but young Fontaneda became a slave to the Indians, and traveled in the country sixteen years. He was finally liberated and sent to Spain by Menendez about the year 1566. Fontaneda wrote a narrative of his adventures but it is of interest only as furnishing a basis for the remarks made by Herrera respecting the Indies. That historian mentioned many names taken from Fontaneda.

A more disastrous shipwreck occurred in the year 1553. The great Mexican fleet sailed in the spring of that year from Vera Cruz and reached Havana with a thousand persons, including sailors, soldiers, and wealthy passengers. The ships carried gold, silver, and other valuable products. In passing the Bahamas the currents put them out of the intended course, and by a storm they were thrown on the coast of Florida, where most of the vessels were sunk. Of the smaller vessels one returned to Vera Cruz and the other reached Seville in Spain.

GUIDO DE LAS BAZARES, 1558.

Philip II became King of Spain in the year 1555, and then the Viceroy of Mexico was Don Luis Velasco. New orders were sent for the conquest and settlement of the vast regions north of the Gulf of Mexico. There public affairs had flourished under Velasco, and much treasure had passed to Spain. The field of discovery was extended northward, and in the year 1555 a mining establishment was opened in the valley of one of the branches of the Rio Bravo del Norte. This for a long time was the most northern settlement in New Spain.

In the council of the Indies in 1557 it was decided to send an expedition to Florida, and in the following year an armament was prepared. The viceroy fitted out eleven ships and collected an army of fifteen hundred officers and men. All were taken by preference who had some knowledge of the country. Some who had been shipwrecked were included, and some who had been held as slaves by the Indians. Some Indians who had adopted Spanish customs were accepted.

Among the captains of this army (says Barcia) were six who had been in the province of Coça, and there for a time kept in slavery. The province of Coça (Coosa) is often mentioned by the historians of De Soto, but no writer mentions the return of the captives to Spain. The command of the army and fleet was given to Don Tristan de Luna y Avellano, a son of the Marshal Don Carlos de Luna. As usual a preliminary examination was made to find a harbor proper for the fleet. The reconnaissance was conducted by Guido de los Bazares, and this was probably his first service, as his name is not mentioned in any earlier record.

Velasco, the viceroy, gave to Bazares three small vessels with sixty soldiers and sailors, and the fleet left Vera Cruz on the 3d of September, 1558, with instructions to examine the whole of the north shore of the Gulf. Bazares sailed to Panuco and from thence coasted north. He landed at a place on the coast of Texas, and proceeding some miles northward found a large bay which he called Bahia de San Francisco. This was probably Matagorda Bay. He then went (as he says) to the "Alacrans," and seems to have passed along the coast to the east of the Mississippi. Much shoal water was traversed. He named the place Bay of Shoals, and it was probably Chandeleur Bay. Going eastward 10 leagues he entered a spacious port, and named it Bay of Philip, in honor of the King. This was Pensacola Bay. "On the whole coast (says Bazares) no port is to be found so commodious as this Baia Felipina." He found 3½ fathoms of water on the bar. The breadth of the entrance is given as half a league, and on one side was an island 7 leagues in length. In the back ground of the bay, hills of red clay were seen. Bazares sailed eastward 20

leagues from Pensacola entrance, and then observed that the trend of the coast changed to southeast. He was twice beaten back by contrary winds from the vicinity of Cape San Blas, and the weather became rough and cold. But, as he had found a port for the expedition of General Luna, he deemed it proper to return to Mexico, and he reached Vera Cruz on the 14th of December, 1558. It is remarkable that the narrative of Bazares contains no allusion whatever to the previous explorations and discoveries along the coast of that vicinity by Maldonado and Arias Gomez, who had been there repeatedly. Bazares mentions all his results as new discoveries. But as only fifteen years had elapsed some of Maldonado's pilots and companions were probably alive in some of the harbors. Cortes made no mention in his letters of the previous exploring expeditions of Cordova and Grijalva along the coast of Mexico and Yucatan, nor would he allow his soldiers to mention their names in the letters which they sent to Spain.

On the 11th of June, 1559, the fleet of Don Tristan de Luna sailed from Vera Cruz to the northward. The chief pilot of the expedition was Juan Rodriguez. After being seventeen days afloat they reached the mouth of the Mississippi, and eight days afterwards came in sight of the coast of Florida, probably in the vicinity of Cape San Blas.

The expedition of De Luna was unfortunate. Soon after the army was landed a hurricane destroyed the fleet. Only one ship was left, which happily had started for Vera Cruz. The army suffered for want of subsistence. The province of Coosa was sought, but it was a vast wilderness filled with savage tribes. Some of the soldiers perished with hunger and thirst, and others were killed in battles with the savages. In one of the expeditions it seems that they approached the Mississippi and crossed it.

French Protestants had made settlements on the coast of Florida, at places that seemed to threaten the safety of the Spanish silver fleets on the home voyages, and these induced expeditions conducted by the Spanish Admiral, Don Pedro Menendez de Aviles; he was an officer of distinction, and had served under Charles and Philip II. In the American colony he had gained wealth. His only son commanded the Mexican fleet, which, as already stated, was cast away on the coast of Florida, in the year 1553. Eleven years afterwards when liberated from an accusation, he requested permission and assistance for sending an expedition to Florida. The grant was conferred by the King, on condition that Menendez should make a survey of the Florida coast, and try to effect some settlements. His fleet was, therefore, in lieu of a searching expedition enlarged to the number of ten vessels, which carried six hundred men as officers, soldiers, sailors, and landsmen. The conditions in his instructions enjoined that within three years he should explore the country of Florida, including inlets and bays, and "mark them so that they could be laid down on the sea charts and made known to mariners; he was to survey the ports, rocks, and currents, and make a description of them, so that the secrets of the coast might be brought clearly to light." Meanwhile it was expected that he should settle six hundred men to cultivate the country, plant sugar cane, and erect forts for defense, as amongst the valuables landed were one hundred horses, two hundred head of cattle, four hundred swine, and the same number of sheep and goats. The outfit was ample, and the privileges extensive.

But when Menendez was about to sail it became known in Spain that French Huguenots had settled on the coast of Florida, and it was also said that French reinforcements were to follow. The Spanish King, therefore, enlarged the commission of Menendez, and authorized him to attack and promptly destroy any heretics found in Florida. The entire armament consisted of thirty-four vessels, and upwards of twenty-six hundred men. Menendez was made perpetual Adelantado, hereditary Governor, and Captain-General of Florida. He hastened to that coast, came suddenly upon the French, and destroyed them in September, 1563. After erecting some fortifications he sailed to Havana, and was there joined by all the vessels of the fleet. Further means were then taken for search respecting his son. Some ships were sent to Saint Augustine, and in person he went to the west side of the peninsula on the 10th of February, 1566. At Charlotte Harbor he found some Christians held as captives by the Indians. These he liberated, but he could hear nothing concerning his son. He passed along and examined the Florida Keys, in March 1566, but no sketch or map is extant if any was made.

Of the geographical names introduced by Menendez only two deserve mention. One is Tegeste, for a place near Cape Florida, and the other is Tocobaga, for an Indian chief and tribe

near Apalachee Bay. Both names are frequently mentioned by Herrera, and doubtless he took them from Menendez. The names occur on maps of the period, and on some were applied to the greater part of Florida.

After many struggles with the French, with the Indians, and even with his own soldiers, and some excursions east and west on the peninsula, Don Pedro Menendez returned to Europe in the year 1567. The King (Philip II) gave him 200,000 ducats, and made him Governor of Cuba.

In the year 1573 Don Pedro Menendez de Aviles gave the government of Florida to his nephew, Menendez Marquez, who undertook some nautical surveys along the Atlantic coast.

FRENCH AND ENGLISH ADVENTURERS, 1555-'67.

French and English privateers followed Spanish navigators at an early date in the West Indies. One English adventurer is mentioned as appearing at Porto Rico as early as the year 1519. The French seem to have led the advance in the Gulf waters.

Spanish historians relate that shortly before the arrival of De Soto the town of Saint Jago de Cuba had been visited by a French pirate, and that another pirate arrived at Havana in August, 1538, and destroyed the town. This seems to be the earliest intimation of the presence of Frenchmen in that quarter.

Hakluyt mentions as the first English adventurer in the Gulf of Mexico a certain Robert Tompson, who had settled at Seville with another Englishman named Fields. Both obtained a royal license to go on commercial affairs to the West Indies. At the Canary Islands they embarked on a Spanish vessel commanded by Capt. Leonard Chilton, who had married in Cadiz. The owner of the ship was John Sweeting, an Englishman, who had settled in that city. They sailed in company with other vessels, and by way of San Domingo reached Vera Cruz in April, 1556. So far as we know, this is the first English voyage to that part of the Gulf of Mexico. Tompson's travels into the interior of Mexico have no interest for our narrative of coast discovery or development.

Roger Bodenham, another Englishman settled at Seville as a merchant, also went to Mexico. He says that he embarked on that Mexican fleet that crossed the ocean under command of Don Pedro Menendez in May, 1564. But the date thus given is erroneous, as it is known that Menendez sailed in June of the year 1565. Moreover, his expedition went only to the east coast of Florida. It is true, however, that Menendez conducted a great merchant fleet across the ocean in the year 1556, and possibly Bodenham went out with that fleet. We know that the son of Don Pedro Menendez was shipwrecked with a returning Mexican fleet in the year 1553 on the coast of Florida.

Hakluyt mentions the voyage of a certain John Chilton, and also the voyage of Henry Hawkes, both of whom went to Mexico. But these peaceful excursions were followed by warlike expeditions.

Sir John Hawkins, in the year 1562, took negro slaves to San Domingo, sold them there, and with the proceeds took a valuable cargo, and returned to England by way of Florida Keys. He was again in the Gulf three years later, having sailed from England with three vessels on the 18th of October, 1564. On that voyage also he took slaves to the West Indies, and compelled the Spanish settlers to buy them at his own price.

After traversing the Caribbean Sea, the vessels arrived at Cape San Antonio on the 17th of June, 1565. By currents the navigation became difficult, but after some trouble he again entered the Gulf of Florida. Hawkins was the first Englishman who explored the Tortugas Islands, and in July he passed the Bahama Channel and coasted along the east side of the Florida peninsula.

For his third voyage Hawkins sailed from Plymouth in October, 1567, with six vessels. Passing as before by way of the coast of Africa, he took negroes, went to the Caribbean Sea, and from thence to Cape San Antonio. But, when near that cape, he was encountered by a furious storm on the 12th of August, 1568, and was forced into the Gulf. While seeking a port on the west coast of the peninsula, a hurricane from the eastward constrained him to cross the Gulf and take refuge in the port of San Juan de Ulloa. On the way, however, he captured three Spanish vessels with passengers, in the hope that he might procure water and provisions as their ransom.

The port of Vera Cruz was entered without opposition; but a few days after the arrival of Hawkins he was attacked by a Spanish fleet which had brought out the new Mexican Viceroy, Don Martin Henriquez. Many of the English were killed, some were captured, and only two of the ships, the Minion and the Judith escaped. These were soon after separated, and in the Minion, the commander with a shattered vessel floated fourteen days on an unknown sea. On the 8th of October they reached land somewhere near the mouth of the Rio de las Palmas, the boundary between Mexico and Florida. At Vera Cruz some of the crews of the wrecked vessels had been taken on board of the Minion. The ship was so much crowded that some of the company preferred to risk their lives on shore, either amongst the Indians, or by trusting to the benevolence of Spanish settlers. After taking in water for the voyage Hawkins sailed, and after enduring many hardships arrived in England on the 20th of January, 1569. Doubtless the party left, about one hundred, landed near the River Santander. Differing in regard to the best course for their extrication, fifty of the number traveled along the coast southward, in hope of finding a Spanish settlement. The others went northward. They chose as captains or leaders John Hooper and David Ingram. But being soon attacked by hostile Indians, twenty five of the party returned and joined those who had traveled southward. The remaining twenty-five kept on northward and with them was Ingram. They marched towards the Rio Bravo; but nothing is known of their fate.

Hakluyt mentions only one other English captain as having entered the Gulf of Mexico, up to the close of the sixteenth century. This was William Michelson, in the ship Dogge, who chased and captured several Spanish vessels. He was, however, encountered by a Spanish man-of-war and narrowly escaped capture. As a companion of Hawkins, one who in time became famous, was Sir Francis Drake. He was in the Gulf in 1568. Hakluyt seems to have been the first in the issue of sailing directions, but the notes were probably transcribed from Spanish documents, as the orthography of the Spanish names is perfect. The descriptions, however, make no reference to points above the twenty-fourth parallel, nor to harbors of the north and west coast of the Gulf; but the Florida Keys and the Tortugas are mentioned. At this time no sailing directions had been compiled in Spain. After the disastrous expeditions of Narvaez, De Soto, Luna, and others, a Spanish author of the period exclaims: "To the south! to the south! there lie our treasures," and that feeling seems to have been general amongst his countrymen.

On the Atlantic coast also where the Spaniard Gomez had coasted even to New England, and Menendez had planned a colony on Chesapeake Bay, progress was stopped. On the Pacific coast, Cabrillo and Vizcaino had passed above Cape Mendocino, but nothing was done afterwards for more than a hundred and fifty years. Occasionally some earnest religionist offered for a missionary tour to the north, but the attempts made did not prosper.

Some disastrous shipwrecks induced orders for the survey of the Florida Keys and other parts of the coast, but no record is left if the surveys were made. Each year the Spanish fleets, with treasure from the Mexican mines, made their voyages through the middle and northern parts of the Gulf, but it is not certain that any vessel at that time passed into the Mississippi Delta. The settlements founded by Cortes in Yucatan and Mexico were maintained, and attempts were made to extend them northwards, but the progress was very slow.

Usually the fleets from Spain passed south of Dominica or Guadaloupe, and sailed along the southern coasts of Porto Rico, San Domingo, and Cuba, and then rounded into the Gulf by way of Cape San Antonio. Menendez, in the year 1567, was the first navigator who entered from the eastward against the Gulf Stream in order to reach Havana, but in general the custom was retained to sail by the south shore of Cuba. From Cape San Antonio to New Spain two routes were used, one for summer and the other only in winter. These were defined by the Alacrans and other dangerous reefs. The landmarks relied on for arrival on the coast of Mexico were the high peaks of Orizaba and the hills of Saint Martin. These were noticed by Grijalva in the year 1519. Between September and April, when northers were likely to happen, ships kept further from the coast and went outside of the Alacrans, the Vermeja, the Triangle, and other banks and reefs of the coast of Yucatan.

Amongst the sailing directions quoted by Hakluyt from the Spanish authority was the following: "If, being near the Tortugas, you sound and find white sand very fine, you are east and west

with them, * * * but if black sand is brought up you are north and south with the Tortugas."

MENENDEZ, 1573.

When the Admiral Don Pedro Menendez was granted by the King the government of Cuba, a nephew, Pedro Menendez Marquez, was commissioned in the year 1573 to make a survey of the coasts of Florida. Barcia says that Marquez had on this occasion no cosmographer, and that no sea chart could be made; but he made such a description of the coast that "the chart could be constructed afterwards." In this way, doubtless, it was treated by the cosmographer, Don Juan Velasco.

It seems probably that what we call the Marquesas Keys take their designation from the navigator.

In the year 1579 order was given for a survey of the eastern coast of Florida, and that latitudes and distances should be registered. But the order was disregarded, as the President of the Council of the Indies left his place before the survey was commenced.

NEW MEXICO, 1581-'83.

In the year 1581 the Franciscan friar Augustine Ruiz set out from the valley of Saint Bartholomew, in Mexico, for exploration to the northward. With eight soldiers he reached the upper valley of the Rio Bravo, and that, since the time of Coronados, has been named the province of Tiguas, or Tiques. There, at a distance of 250 leagues from Santa Barbara, the soldiers left through fear of the Indians and made their way to Mexico. But Ruiz and the friar Francisco Lopez remained with the natives, who seemed to be friendly. Anxiety in regard to them induced the sending of another member of the order, Friar Bernardin Beltram, and he went out accompanied by some soldiers.

There was then a wealthy settler in the valley named Antonio Espejo. He was a man of great courage, offered to lead a northern expedition, and also meet the expenses, provided that certain advantages should be conceded to him. This was done. He gathered a company of soldiers, procured horses, mules, munitions, and victuals, and started from the valley on the 10th of November, 1582. He traveled along the course of the great Rio del Norte, passed many Indian tribes, and named the country New Mexico. On his route he was told that the Indians had killed the two friars, Ruiz and Lopez, and the natives mentioned also the passage of Narvaez through the region. West of the river they sought Acoma and Zuñi and were informed of the march of Coronado. Some Spaniards remained there after his time.

Espejo went further west, but most of his companions left the service, and returned by way of the Rio Bravo to Mexico. With those who remained he seems to have passed to the headwaters of the river, and then went eastward. They were in the Buffalo country in July, 1583. Finding a river running south they went in that direction 120 leagues, everywhere finding herds of cattle. They, no doubt, thus traversed the western part of the State of Texas.

Soon after these discoveries by Ruiz and Espejo, the military expedition of Oñate set out, and as a result the city of Santa Fé was settled. In a work printed at Madrid in 1586 it is plainly stated that the Rio Bravo empties into the Gulf of Mexico. But long after some European geographers represented that river as emptying into the Gulf of California.

Barcia relates that in the year 1592 a certain Friar Diego Perdonio returned to Mexico after traversing a great part of Florida, but the particulars of his journey are not known.

A Spaniard, Omaña, is mentioned by Barcia as having started from the Rio Bravo to go eastward, and that at a distance of 150 leagues he arrived at a river 1 league in breadth. This may have been the Red River or the Mississippi.

In the year 1613 there were English settlements on Chesapeake Bay, on ground then regarded by Spaniards as the eastern coast of Florida. To Spaniards the motions of the English seemed to be encroachments, and in consequence the attention of Spanish settlers was drawn to intermediate countries, in particular to the valley of the Mississippi and the valley of the Rio Bravo. Two enterprising captains, Joseph Triviño and Bernarbé de la Casas, offered to settle the lower

part of New Leon, as the region around the Rio Bravo was then called. As late as the middle of the eighteenth century that region included the greater part of Texas. Permission for the conquest was sought from the Marquis de Guadalcaçar, who was made Viceroy in the year 1612, but he would not give his consent, preferring to send all papers relating to the proposal for the decision of the King of Spain. Nothing is known of the result. Mention is made that in the year 1630 a Portuguese captain, Vincente Gonzales, sailed up a large river which emptied into the Gulf of Mexico. Some have supposed that it was the Mississippi, but the notice is so vague that no inference can be founded upon it.

During the Thirty-Years War, privateers and pirates had no restraint, and buccaneers flourished. In one port of Flanders alone could be counted, in the year 1634, not less than three hundred barks manned by pirates. Dutch, English, and French filibusters were chasing Spanish ships in all directions. In 1640 the buccaneer Pierre le Grand, from the Tortugas, with a band of twenty-eight desperadoes, attacked the ship of the Spanish Vice-Admiral of the Mexican fleet, and took all the treasure found in the vessel to France.

Some years earlier the Mexican fleet when passing through the Bahama channel was met by a heavy storm. Some of the vessels were wrecked on the coast of Florida; the Admiral's ship foundered, her papers were lost, and thus the affairs of Florida were brought into confusion. Only two of the ships escaped and finally reached Cadiz.

Early in January, 1656, Spanish galeons sailed from Havana with the Marques Monte Alegri, but by a furious gale were soon driven back and scattered in the Gulf. The flag-ship was lost, and the disaster was so notable that Don Diego Portiachuclo de Ribadeneira, a prebendary of Lima, wrote a history of it, which was printed at Madrid in the following year.

It is probable that a Spanish navigator in the year 1669 went up the Mississippi, and also up the Ohio, but there is no detailed record of the voyage. Mention is made in a general way of the voyage of an Englishman to the mouth of the Mississippi in the year 1670.

The Governor of Florida, Don Juan de Hita y Salaçar, seems to have given attention to the southern part of Florida and the keys, and probably was moved by the disastrous shipwrecks. To the council he represented the need of a survey of the dangers, and he proposed a mission for civilizing the Indians. The country to which he refers as that of the Cazique Carlos was the region about Charlotte Harbor, and he included the Florida Keys. As a result it is only known that one Franciscan missionary went over to the Indian provinces, by which is meant the coast opposite to the port of Havana.

ROBERT DE LA SALLE, 1682.

The Canadian Sieur Nicolet appears to have been the first who reached some tributary of the Mississippi. In the year 1639 it is believed that he was on the waters of the Wisconsin. Thirty years later the same river was found by the Jesuit father Allouez. But, amongst Frenchmen, Father Marquette and his companion, Sieur Jolliet, were the first who reached the main channel of the Mississippi. They passed out of the Wisconsin and into the waters of the main river on the 17th of June, 1673. Marquette and Jolliet had several conjectures in regard to the probable direction of the stream. By them it was deemed possible that it might end in Chesapeake Bay or some other estuary of the Atlantic. So also in the uncertainty, it might go westward into the Pacific, or pass southward into the Gulf of Mexico. They went south to the vicinity of the mouth of the Arkansas, and finding the course not changed, the conclusion was that it emptied into the Gulf. The party turned back on the 17th of July, 1673, and arrived in Canada at the end of summer. Father Marquette put on his maps "Conception River," but in his journal it is invariably written "Mississippi." The name is of Indian origin and was known under other forms, as "Mesi-sipi," "Metchisipi," &c. By the Indians it was made known to the French before it had been seen by the missionaries.

Robert de la Salle, when commanding Fort Frontenac, on the shore of Lake Ontario, was informed of the existence of the great river, and planned an expedition to complete the work of exploration as it had been left by Marquette and Jolliet. He intended to pass down the Mississippi to its mouth, take possession, and develop for his own and his country's benefit and glory

the resources of that central artery of North America. In May, 1678, he obtained a patent from the King of France "to endeavor to discover the western part of New France, through which it is probable a road might be found leading to Mexico." He was also authorized to erect such forts and habitations as might be needful for his purposes. At some point west of the Falls of Niagara he built a ship, and passed into Lake Michigan with provisions. A small fortification was erected, and another on the banks of the Illinois River, in order to secure his route on the return. After many difficulties he began the descent of the river in canoes on the 13th of January, 1682, with twenty-one Frenchmen and a number of Canadian Indians. Father Zenobe Membré, who was one of the party, wrote a report of the voyage, and Sieur Henri de Tonty, the most active associate of La Salle, subsequently became an energetic explorer in the same region. In the narratives of that time the Mississippi is mentioned as "Rivière Colbert," in honor of the prime minister of France, the patron of La Salle. Some of the contemporary accounts name the region through which the river flows "La Louisiane," in honor of the King of France. The expedition passed the mouths of the Ohio and the Missouri, and on the 12th of March was at the mouth of Arkansas River. Some Indian tribes were passed on the route, probably the same as had been mentioned in the report of De Soto. The mouth of the Red River is indicated erroneously, and no name is attached to the river.

On Easter Sunday (29th of March) the explorers arrived at the Delta of the Mississippi, and on the 6th of April reached the shores of the Gulf of Mexico. Three bands were then equipped to sound and explore the passes of the river. La Salle took the western side, M. de Tonti the middle channel, and Sieur Dautray the eastern pass. All the channels were found to be navigable, and were reported as being deep. The parties again united on the 9th of April, and with religious ceremonies "took possession" of the country. La Salle wished to explore east and west of the Delta, but want of provisions obliged him to return. He started northward on the 10th of April, and in September was again at the port on Lake Michigan. In the year 1685 he was again in France preparing an expedition for moving up the Mississippi. The issue of the adventure was unfortunate. Two years later, after having traversed the region watered by the great river, La Salle, in 1687, was killed by mutineers when he was endeavoring to get back to New France. The force which he led was ample. In four vessels he took two hundred and eighty persons—soldiers, workmen, and mechanics—with implements, provisions, and munitions for the establishment of a fort. On the 1st of August, 1684, the vessels sailed from Rochefort, and after passing into the Gulf of Mexico were apparently moved by chance towards the Delta. They passed far to the westward of the entrance, and at last anchored in Matagorda Bay. Excepting the commander, all were discouraged, and two of the vessels returned to France. La Salle remained with one vessel, and from a camp near the entrance of the bay made several excursions in hope of finding some branch of the Mississippi. By a series of mishaps his vessels were all destroyed, and he was thus deprived of the possibility of succor from the French colony at San Domingo, to which the intention was to have recourse in the event of disaster. Hence it was essential to reach the Mississippi by land in order to communicate with France by way of Canada. On the 22d of April, 1686, he set out on a northeastern course, probably to avoid the marshes and river mouths. Many streams were passed before he reached a place inhabited by Indians. The savages received the Frenchmen in a friendly manner, and promised favor to all of that nation.

Here La Salle fell dangerously ill, and was detained by fever during two months; and in that period much of the provision was consumed by his party. Some of his men deserted, others died. The commander was thus constrained to return to the fort, which he reached after an absence of six months, on the 17th of October, 1686. He again took the field on the 7th of January, 1687, leaving the fort in charge of the Sieur le Barbier, but at some point between the Brazos and Trinity River he was slain, as already related, on the 19th of March, 1687, by some reckless members of his party.

The French had been anticipated in this region. La Salle and his men found Spanish horses in common use amongst the Indians, and some of them were procured for the transportation of the baggage. Moreover, some of the Indians were in Spanish costume, and were possessed of iron tools and silver spoons. Some pictures of saints and papers were found amongst them, and a few Spanish words were in use, as "capita" for *commander*, and "cohavillo" for *horse*. The

Indians were much in fear of the Spaniards, and frequently mentioned that inroads had been made in their country from the northwest.

The conspirators who murdered La Salle resolved to settle in the country of the Cenis, but soon quarreled among themselves, and some of the ruffians were thus killed. The adherents of La Salle continued his intended exploration, and again set out in June, marching to the northeast. Amongst them were a brother and a nephew of La Salle. Several large rivers were crossed, and on the 27th of June they crossed what is, doubtless, Red River. At the end of July the mouth of the Arkansas was reached, and at the first French habitation the party embarked, on the 1st of August, to return to Canada. Few of the names given by La Salle and his French companions to rivers and places in Texas are now known in geography. One exception is that pertaining to the little river near his Fort Saint Louis, namely, "La Riviere des Bœufs," which the Spaniards translated as "Rio de las Vacas," and which is at present known as *Lavaca River*.

In the summer of the year 1685, La Salle's friend, the Sieur Henri de Tonty, was notified from France that La Salle had sailed for the mouth of the Mississippi. De Tonty therefore embarked in the autumn of the same year for the south end of Lake Michigan, and left Fort Saint Louis on the 16th of February, 1686. He reached the Gulf, but finding no trace of La Salle, sent out two canoes to make search. One of these went westward towards the coast of Mexico, the other went eastward. Each made about thirty leagues and then stopped for want of fresh water. De Tonty noticed that the Gulf waters rose and fell "not more than two feet perpendicularly on the coast." He found also the cross with the arms of the King of France, which La Salle had set up in the year 1682. It had been displaced by floods, and was therefore removed and set at a point on higher ground about five leagues further up the stream. De Tonty addressed a letter to La Salle and left it in the care of some Indian chief at the Mississippi delta, and that letter was found fourteen years afterward in possession of the same Indians by the French officer Bienville.

De Tonty was a man of uncommon energy. After thorough search for La Salle in vain, he proposed to his companions to return to Canada by way of the coast of the Atlantic. The members of his party were unwilling to leave a known course, so turning back they kept along the Mississippi, and arrived at Montreal near the close of July, 1685. He introduced the name "*Red River*" in our geography, and says of it: "The Indians call this great river *Riviere Rouge*, because it deposits a sand which makes the water as red as blood." De Tonty states that he made a map of the Mississippi River, and that the map was sent to France, but nothing is known respecting it.

JUAN ENRIQUEZ BARROTO, 1685.

Information respecting La Salle's voyages was sent to Mexico by Don Andres de Ochoa y Carate, commander of the Spanish fleet in Gulf waters. He obtained the particulars by the capture of a French privateer on the coast of Yucatan. On receipt of the intelligence the Marques de la Laguna, Viceroy of Mexico, sent at the end of the year 1684 a pilot named Barroto to Havana, with order to the Governor of Cuba that without delay a vessel should be made ready for an expedition to the Gulf.

Barroto is recorded as "a distinguished mathematician, and a man of great experience in these waters." He was intrusted with the command and was instructed to sail to the bay of Apalache, and then to examine the coast for any settlement that La Salle might have established. He left Havana in January, and "registered" the bays and capes of the north coast, more particularly that part between Apalache Bay and the cape which he calls Cabo del Lodo [Cape of Mud]. He traversed also the Baia de Santa Maria, which is now known as Pensacola Harbor. But no settlement was found, nor any trace whatever of Europeans. Many hardships were encountered, and he was obliged to return to Vera Cruz. Barroto sent a narrative and chart to the Marques de la Laguna, who transmitted the documents to the King. The chart is not extant, but the report mentions the name Cabo de Lodo [Muddy Cape] as applied to the projecting spits and broken ground at the delta. That name appears on all Spanish charts of the eighteenth century.

At the end of the year 1686 another viceroy, Don Melchor Portocarrero, Count of Monclova, arrived in Mexico with a commission which authorized him to expel the French from the Gulf,

and to destroy their settlements. He reached Vera Cruz in September, 1686, and assembled a counsel of pilots and commanders, and by them the chart made by Barroto was inspected. The viceroy learned as the result that Barroto had not closely examined the coast, and that foreigners might be where Barroto had not been. Two armed vessels were prepared to expel the French, and, as was then usual on such occasions, two smaller vessels were fitted out to make preliminary search. These were intrusted to the command of Don Martin de Ribas and Don Pedro de Iriartè, but the chief pilot was Barroto.

The vessels sailed from Vera Cruz on the 1st of January, 1687, for the bay of Apalache, but violent storms and contrary winds in crossing the Gulf delayed the passage so that Apalache was not reached until the beginning of May. It seems probable that the experience of the pilot Barroto as a navigator alone saved the vessels from destruction. They finally entered a spacious bay and found two fathoms of water on the bar. The wrecks of two French ships were seen near the entrance.

La Salle was killed in March, 1687, but some of his party were then living at Fort Saint Louis. The survivors sailed for Havana because the winds were unfavorable for Vera Cruz, but to that port they turned after a stay of three days on the coast of Cuba. At Havana they had been given up as lost in the furious storms that prevailed in the spring of the year. The viceroy therefore hastened the departure of two armed vessels under the command of Don Andres de Pes and Don Francisco Gomarra. They had the distinguished pilot Luis Gomez Raposo, and examined the entire coast of the Gulf. On reaching Saint Bernardo or Saint Luis [Matagorda Bay] they also saw the remains of the two ships of La Salle's expedition. Having closed the examination, they arrived at Vera Cruz on the 14th of September, 1687. Barroto had already reached that port.

As successor to the Count de Monclova, the Conde de Galva arrived in Mexico and became Viceroy in the autumn of 1688. Soon after it was known to him that in the frontier settlement at the north, three Frenchmen had appeared who stated that other Frenchmen were yet alive in that region. Orders were given to search for the French. A year earlier Alonzo de Leon had erected a small fortification south of the Rio Bravo and named it in honor of the Viceroy "Fort Monclova." From thence, in January, 1689, he set out at the head of a party of horsemen and went north and northeast, accompanied by a geographer who was to take particular notice of discoveries. After a long march a lagoon was reached and was named San Bernardo. Fort Saint Louis had been abandoned. Eighteen pieces of cannon were found scattered on the ground and some dead bodies of the French invaders. The Indians said that five Frenchmen of the expedition were yet alive in the "Provincia de los Texas," which was a hundred leagues distant. This name appears to designate the country and a Indian tribe which La Salle named the "Cenis."

By Indian messengers Leon sent a letter to the five Frenchmen, and two of them came to him. In the month of May he presented them to the viceroy of Mexico, and to that official they made known the history of the expedition of La Salle, including mention of his settlement at Saint Bernard's Bay, his movement along the Mississippi and his ultimate fate.

To preserve the power of Spain the viceroy resolved that the Gulf coast should be settled; that the province of Texas should be provided with defenses, and that possession should be taken of the best naval position near the mouth of the Mississippi. For strengthening the armament at Pensacola, Andres de Pes was sent to Spain to make due representations at court. To favor settlements in Texas several small forts and missions were established in the year 1690, and Don Domingo Terau was appointed Governor of "the provinces of Coahuila and Texas." But this effort of the Spaniards to settle that country was unfortunate. Indians were numerous; the cattle died, and the crops failed. In the year 1693 only a few Spaniards remained in the province.

On the 25th of March, 1688, a Spanish force sailed from Vera Cruz. The war ship was secured in Mobile Bay, and the smaller vessel passed westward to the mouth of the Mississippi, which river was then known as Rio de la Paliçada. The earlier name "Rio del Espiritu Santo" was apparently then forgotten. The adventure was fruitless and the vessels were again at Vera Cruz on the 10th of May.

Under the orders of the viceroy, Andres de Pes went to Spain, and the King, pleased with his intelligent and patriotic exertions, named him Admiral of the Mexican Gulf fleet; and for

services already rendered conferred on him the habit of the order of St. Iago. He returned to Mexico in the year 1692 with the royal sanction for completely fortifying Pensacola.

In the following year (April 8, 1693) two Spanish vessels, under the direction of De Pes, entered Pensacola Bay, and the learned Professor Siquenza at once declared that it was the same harbor in which Pamfilo de Narvaez disembarked, and which Diego de Maldonado had discovered under the name of "Achusi" in De Soto's time. Pes and Siquenza examined all the shores and indentations in boats, and gave names to the points, capes, bays, and rivers. Many of the names appear on charts of the present day. At Mobile Bay the same navigators explored only near the entrance but did not enter the body of the bay. Keeping on westward they came, on the 1st of May, to a point which they named "San Miguel," and judging that there might be some passage towards the Mississippi they entered with boats, but found only broken ground. Through a narrow channel they entered a large lake, but beyond it could not pass into the river, and in consequence they returned to their ships. The name Punta de San Miguel on later Spanish charts is marked at the eastern entrance of Lake Borgne. De Pes was afterwards Governor of the Indian council, and one of the chief officers of the Spanish Admiralty. In the inscription on his monument he is styled "*Sinus Mexicani Scrutator.*"

De Soto's pilot, Maldonado, had reported Pensacola Bay (then called Saint Mary's) as being the most convenient place on the Gulf for a marine and military establishment, but no settlement was made there until the year 1696, when Don Andres de Arriola went from Vera Cruz and built a fort. But its position was commanded by higher ground, and there was no fresh water inside of the lines of fortification. However, no foreign enemy was to be feared, and the neighboring Indians only were kept in view. No fears seem to have been entertained respecting the French. The soldiers of Arriola understood from the Indians that they called the country around the bay "Pançacola," which they said was the name of a nation that had been dispossessed by the present owners of the ground. Arriola is styled in the contemporary record "The first Governor of Pançacola."

IBERVILLE, 1698-'99.

Lemoyne d'Iberville was a Canadian gentleman; had shown resolution in opposing the English in Nova Scotia, Newfoundland, and Hudson's Bay. He had traversed immense tracts of land and water, and after expelling the English from Hudson's Bay he aimed at establishing French empire in North America, and deeming the control of the Mississippi essential he persuaded the French minister, Count Pontchartrain, after the peace with England in 1697, to attempt the occupation of the mouth of the great river.

Pontchartrain ordered the arming of two men of war at Rochefort, and gave the command to Iberville. One account states that Chateaumorand joined the expedition at San Domingo with the ship Le Francois. Iberville was accompanied by two of his brothers, namely, the Sieur Lemoyne Bienville and the Sieur Lemoyne Souvole, and both of them were distinguished in the history of discovery. The expedition sailed on the 17th of October, 1698, and made the passage into the Gulf of Mexico by way of San Domingo. It was accompanied by the French adventurer Laurent de Graff, or Grave, who had made himself formidable to the Spaniards under the name of "Lorencillo." He seems to have served as pilot and guide.

Iberville and Chateaumorand reached Pensacola on the 25th of December, and there to their disappointment found a Spanish fort. So keeping on westward they came to the entrance of Mobile Bay, and landed at Dauphine Island. Here were found skeletons of human beings, and some authors judge that they were the remains of the unfortunate followers of Narváez in the year 1529. Passing on, Iberville took soundings and anchored near an island, which from that incident was then named "Ship Island." On the 11th of February a little bay was entered, and from an Indian tribe was named "la Baie de Biloxis." Soon after a river mouth was seen, and from another Indian tribe was named "Rivière des Pascagoulas." Having received from the natives information about a great river which they called "Malbouchia," Iberville and his brother Bienville set out on 27th of February from Ship Island in two boats for exploration, believing that the river indicated to them was the Mississippi. On the 2d of March they entered a large river with turbid waters. After tracing the course for 60 leagues they came to an Indian nation called "Ouma," and

found amongst them prayer-books in which the names of some of the Canadian companions of La Salle were written. The Indians had also, and delivered the letter which Tonti addressed to La Salle in the year 1685. On the 22d of March they arrived at a narrow and shallow branch of the river leading eastward. Two lakes were found and named Lac Maurepas and Lac Pontchartrain, and a few days afterwards Iberville was joined (March 31) by his brother Bienville at the ship station. On the 12th of April a little bay was entered and was named "La Baie de Saint Louis," but the water being shallow, it was decided to settle at Biloxi. A fort was built, and was manned by thirty-five of the followers of Sauvole and Bienville. Iberville on the 4th of May set sail for France, intending to bring an additional force for the settlement.

In the course of the summer of 1699 Sauvole and Bienville made excursions in the vicinity of the fort to gain the friendship of the natives. At the end of May, Bienville set out for Pascagoula River. Six feet of water was then found on the bar.

On the 9th of June a land journey was made to Mobile Bay, and the party passed on from thence to Pensacola Bay to observe the action of the Spaniards, who were then found to be established in their fort.

In July two missionaries and a number of Canadians arrived at Biloxi. When told by Indians of the new French settlement they descended the Mississippi in two canoes and thus joined with countrymen who had reached the same region by way of the Gulf of Mexico.

At a bend of the river, 28 leagues from from the sea, Bienville, to his great surprise, found an English vessel armed with twelve guns and commanded by a Captain Barr. When notified that he was an intruder the Englishman left, but threatened to return in the following year. This meeting was on the 15th of September and the place has since that date been called "le Detour aux Anglais," *i. e.*, the "English Bend."

On the 7th of December Iberville reached Biloxi after his visit to France, and with him came officers and passengers in the ships La Renommée and La Gironde.

Grants seem to have been conferred upon a Colonel Wood, of Virginia, who was there resident between 1654 and 1664; and again in the year 1678 a number of persons are said to have moved from New England for discoveries in New Mexico, but only casual mention can be found of these undertakings.

When the English settled in Carolina, they claimed all the territory westward to the Pacific Ocean. Charles I, of England, had granted by patent to Sir Robert Heath, then attorney-general, the undefined region. By him it was transferred to the Earl of Arundel. It is beyond doubt that English adventurers arrived on the lower Mississippi as early as the year 1699. Bienville, the Frenchman, states that on the 23d of April of that year he was informed by Pascagoula Indians that on the 21st of that month two Englishmen, with two hundred Chicasaws, had plundered and destroyed one of their villages. The narrative of Dr. Coxe mentions that he fitted out two vessels for exploration. These sailed from England in the year 1698, under the command of Captain Barr. One of the vessels had an armament of twenty-two guns, the other of twelve guns. In the summer of 1699 they were in the Gulf of Mexico, and had as pilot the French engineer Secou.

Captain Barr seems to have at first entered the bay east of the delta, and he calls it Nassau Bay, the same (says Daniel Coxe) "which the Spaniards designate as Spiritu Santo Bay." After passing the islands of Mississippi Sound, Barr entered Mobile Bay. This was probably near the close of the year 1699. On the homeward voyage one of Barr's vessels was wrecked on the coast of England and officers and men were lost; but the journal and a full account of the country along the coasts were saved.

All the bays, islands, and rivers denoted by Iberville and Bienville can be readily identified, as some of them yet bear the names attached by those explorers: as *Ship*, *Horn*, and *Cat* islands; also the Chandelear Islands, Saint Louis Bay, Biloxi Bay, and Pascagoula River, Iberville River, Lakes Maurepas and Pontchartrain, the Rigolets, and Bayou La Fourche.

In February, 1700, De Tonti again passed down the Mississippi to inspect the settlement at Iberville, as he had fifteen years earlier journeyed in behalf of such as may have been intended by La Salle. The enterprising traveler De Tonti died in the year 1704, at Mobile Bay. He had passed four times up and down the Mississippi. In August, 1706, the active Iberville died of yellow fever at Havana. In the year 1708 a French officer, M. Diron d'Artaguette, arrived from France to act

as commissary, and to decide on the policy of maintaining a port. Massacre Island was examined, the waters of the vicinity were sounded, and when in the year 1711 the settlement at Saint Louis was inundated, Bienville was directed to remove to a position 8 leagues farther down. The place selected was at the delta of Mobile River.

In September, 1712, the King of France conferred the management and commerce of the French colony, in Louisiana, upon an enterprising financier of great wealth, M. Crozat, and as was then common in governmental changes a new impulse was given for explorations. The action of Spain was at that time feeble. Fearing the French they had endeavored to expel them; but they dreaded also the English. This condition was changed after the grant of Louisiana to Crozat. France and Spain lost their common interest. Defense against encroachments by the English, and the grant to Crozat, to which the King of Spain had from the first been opposed, were in Spain regarded as acts of hostility. But Crozat inspired the French in Louisiana with a spirit of activity of which the Spaniards became jealous; and thus further expeditions and discoveries resulted from emulation between the two great powers which had then founded settlements on the shores of the Gulf of Mexico.

By royal decree Crôzat had exclusive right during fifteen years to send products from Louisiana to France free of duty, and to introduce slaves from Africa. He was accorded the monopoly of all mines that might be found in the valley of the Mississippi; was allowed to have his own commissaries and directors for exploring and for making treaties with the Indians, and for guarding his own private interests. The King required merely the transportation needful and provisions for officers and soldiers assigned for defence.

The first vessel sent out under the grant arrived in Louisiana in the spring of the year 1713, with the Royal Governor De la Motte Cadillac and some commercial directors and agents appointed by Crozat. With large views that active man gave attention not only to the fur trade, but also to commerce and navigation through the Gulf of Mexico. His aim was to take merchandise from Louisiana to Pensacola, to Tampico, to Vera Cruz, to Tuspan, and to Havana. By his agents, trading journeys were made along the Mississippi and Red Rivers, and amongst them the most conspicuous traveler was St. Denis, who was well acquainted with the country. In the year 1714 he was sent to the southwest amongst the Spanish missions, then supposed to be in the province, and was authorized to make overtures to the Spanish settlers for intercourse and trade. Attended by a few Canadians and Indians, the energetic St. Denis entered Texas near the close of the year 1715, and stopped in the vicinity which had been occupied by La Salle's companions eighteen years earlier. He traversed the country, going southward and westward, and crossed the rivers, but found no traces of civilization short of the Rio Bravo. A few leagues westward of that river was the military post and mission of San Juan Bautista. St. Denis was received by the Spaniards with kindness. After some time he passed on to Mexico to seek an interview with the Viceroy, who cordially entertained proposals, but stipulated that St. Denis on his return through Texas should conduct some Spanish missionaries who were to settle at different stations on the road.

St. Denis left Mexico on the 26th of October, 1715, and crossed the territory of Texas by the route followed in his advance. His Spanish companions in passing made several little settlements amongst the Adays, the Assinays, and the Natchitoches in the vicinity of Red River.

On the 25th of August, 1716, St. Denis arrived at Mobile. Soon after other settlers and troops were sent to re-enforce the posts founded by him and to establish others. Merchandise was packed for trade with the Spaniards on the Rio Bravo, and on the 10th of October, 1716, the party of St. Denis again set out from Mobile for the journey to Mexico. After reaching Red River several missionary stations were visited. On the 21st of January, 1717, they were at a Spanish "presidio," which was garrisoned by seventeen soldiers. Beyond Trinity River they passed the Rio Brazos, and on the 8th of April the Rio Colorado, on the 11th of May the Rio San Marco, on the following day the Rio Guadalupe, and two days later they forded the Rio San Antonio. The four days following were occupied in traveling 27 leagues to the Nueces River, and on the 21st of April they arrived at the Rio del Norte. There the goods belonging to St. Denis were seized by the Spaniards. He went to Mexico to claim their restoration; but Don Baltasar, who had succeeded the Duke of Linares, put St. Denis in prison. He, however, escaped and

reached Mobile in March, 1719, and found there most of his companions. His expeditions rank high in value, and the routes which he took were carefully marked on maps of the Mexican Gulf countries. They appear on sheets which show the travels of Cabeça de Vaca, Moscoso, La Salle, Cavelier, and other resolute explorers, and from this time the geography of Texas may be regarded as settled.

SAINT JOSEPH'S BAY, 1718.

Crozat did not reap the advantages expected from his Louisiana grant; nor had he advanced the interests of the colony. He therefore (in 1717) renounced his privileges, and Louis XV, of France, accepted his resignation.

Then (August, 1717) the Western Company was formed, and, under the direction of the noted speculator Law, the company aimed at the control of the foreign and domestic commerce of France. The King granted to that corporation privileges more extensive than those which had been allowed to Crozat. They held under his letters patent for twenty-five years the right to all lands, coasts, ports, harbors, and islands pertaining to Louisiana, retaining for the Crown only fealty and homage. They were at liberty also to choose governors and officers for the command of troops. Within the period specified the company engaged to settle in the territory six thousand white persons and three thousand negroes; to make efforts for the salvation of the Indian savages and negroes; to build chapels and maintain religious teachers. Under this grant three ships arrived at Dauphine Island in February, 1719, bringing settlers, soldiers, and goods for commerce with colonists already settled on the Gulf shores. Lemoyne de Bienville, a man of influence, and popular in Louisiana, was nominated by the company as governor. He fitted out a party to move towards Saint Joseph's Bay, intending to make there a military post, as it was not far from Pensacola Bay. To Saint Joseph's, therefore, Bienville sent his brother with fifty soldiers in the year 1718. A fort was erected, and was left in command of M. de Gousy. But the Spaniards, in superior force, soon compelled the surrender of the place, and the fort was destroyed. The name, and a tolerable representation of Saint Joseph's Bay, appear on the maps of the French geographer De L'Isle. In August, 1717, a great storm inundated Dauphine Island and destroyed its harbor by masses of sand. This event necessitated a search for ship protection elsewhere. Bienville found at last, thirty leagues from the Gulf, a place on the Lower Mississippi, and in the year 1718 there built some houses and left men to clear the ground. On this site subsequently arose the city of New Orleans. It was so named in honor of the Bourbon Prince who was then regent of France. On the 19th of April, 1719, M. De Serigny arrived with notice that war had been declared between France and Spain. He brought a commission for exploring the coast of Louisiana in company with Bienville, and he was authorized to gain, if possible, possession of the Spanish fort at Pensacola, as it defended the only good port on the shores of the Gulf of Mexico. Pensacola was surprised by Bienville and Serigny in May, 1719, but in the following month it was retaken by a Spanish force from Havana. Somewhat later a French fleet, under M. de Champmeslin, captured the place; and thus in the course of six months Pensacola had changed masters three times.

In the year 1720 a French astronomer of distinction was sent to Louisiana. This was Father Laval, professor of mathematics at Toulon. His observations were published at Paris in 1728, and with them is included a plan of the harbor of Pensacola. Laval, in June, 1720, set up an observatory on Dauphin Island and observed for latitude. The result found was 37° 17′ 1″ for his place of observation, and he says that he drew the coast line of the entire Gulf 13 minutes further south than it had been represented by earlier map makers.

Laval made observations on the currents, tides, and winds of the Gulf, but his operations were interrupted by pestilence. The pious father, deeming that "science was only an accessory duty for a man of his profession," gave all his time to the care of his sick soldiers and sailors, and as soon as practicable he returned to France

GALVESTON BAY, 1721.

When the King of France ordered the movement against Pensacola he gave at the same time directions for pushing the French dominion to the southwest, indicating the "province of Lestekas" [Texas], of which the Spaniards had possession. The governor of the province, Don Martin D'Alarcone, had in fact by his policy increased the number of settlers.

St. Denis and Bernard de la Harpe had been sent to the French settlements at the north in the year 1719. This expedition of La Harpe was directed to New Mexico, but on his return in January, 1720, to New Orleans he found that the Western Company had issued an order for the immediate settlement of Saint Bernard's Bay, which after the time of La Salle had not been entered by any French officer. Mr. Belisle, in 1717, had been left there, and after many adventures had returned. He was now requested to go under command of La Harpe to take possession of the bay. A small vessel, the "*Subtile*," with twenty men, was assigned to La Harpe, and he was named commandant of the Bay of Saint Bernard. He was to proceed without delay and to take possession of the adjacent country in the name of the company and the King, and to build a fort. Spanish settlers were to be informed that the territory belonged to the King of France, in whose name Robert de la Salle had taken possession twenty-five years before. Intruders were to be driven out by force.

On the 16th of August, 1721, De la Harpe left Dauphin Island and sailed westward "for a hundred leagues or more." At all places where attempts were made to land the natives were hostile. He returned to Mobile and reached that place in the middle of October.

CHARLEVOIX, 1722.

In January the Jesuit father, Charlevoix arrived from Canada, and to him must be conceded a conspicuous place as an explorer and as the historian of early times in the northern region of the Gulf of Mexico. He visited all the French settlements there and gave to the world the first reliable description of the country. He passed down the Mississippi and at the mouth, in company with the French engineer Pauger, he sounded one of the passes. Subsequently Charlevoix was shipwrecked at the Florida Keys, but escaped in a small boat and with it arrived at the Spanish settlement at Saint Mark's. He then passed along the north coast of the Gulf to Louisiana, and finally returned to France.

The principal centers of activity for the Spaniards were Pensacola and Mexico. From these stations the northern and eastern parts of the Gulf coast were explored, and travels were made toward Texas. That territory was, however, relinquished by Europeans in the year 1694, with the exception of Spanish mission stations along the Rio Bravo. In the year 1714 French adventurers again appeared in Texas. If any movements were made for exploration in the interval of twenty years, the results are not known. France and Spain being at peace, travel followed the routes between Vera Cruz, the delta of the Mississippi, Mobile, Pensacola, and Havana.

The movements of St. Denis so aroused the Spaniards that they made alliance with the French discoverer, and sent Don Domingo Ramon with some soldiers and Franciscan missionaries to accompany Saint Denis toward the region watered by Red River. Several stations were chosen and provided with means for sustaining the missions. The province was then named by the Spaniards "*Las Nuevas Filipinas*." The Marquis de Aguayo was the first royal governor, and he entered his province in the year 1716. Some years of peace were enjoyed, and for some time no expeditions, such as had been induced by wars in earlier times, were sent out. With the savage Apaches and Comanche Indians the Spanish contended in the interior; but for the same period there was no naval enterprise. The northwest parts of the Gulf coast were not explored until the end of the eighteenth century, and Humboldt says (in 1812) they were "as unknown as the coasts of Africa."

In the year 1703 Don Juan de Ayala, an active and intelligent Spanish officer, who was well acquainted with matters in Florida, suggested an expedition from Saint Augustine to the Gulf for the conquest of territory between that place and Pensacola. His proposal was laid before one of the most distinguished ministers of Spain, Don Alonzo Carnero, and it included the recommendation that some point on Appalachee Bay should be fortified. Ayala was appointed governor of Florida in 1718, and as no measures had been taken on his earlier suggestion, he then ordered an expedition to move from Saint Augustine toward the northeastern part of the Gulf, and directed also the structure of a fort. The command of the expedition was given to Don Joseph Primo de Ribera, "a soldier of great experience and courage," and he was furnished with all requisites for building a fort in the region inhabited by Indians at Appalachee. A vessel with provisions was sent from Saint Augustine to assist in the operations. Ribera set out by land on the 20th of February, 1718, and arrived at the head of the bay in advance of the ship. He immediately began the con-

struction of a fort, and named it Saint Mark's, but the party was soon in want of supplies, as the vessel did not arrive at the time expected. Some soldiers were therefore sent to Pensacola to ask aid from Don Juan Pedro Matamoras, and provisions were sent by that officer in a little coasting vessel. Meanwhile the ship of Ayala arrived at Saint Mark's.

Bienville (governor of Louisiana) had recalled his commander at Saint Joseph's Bay, as that station was desolate. The greater part of the garrison had previously deserted to the Spaniards, and the remnant reached Mobile in a little vessel on the 26th of July, 1718. The Spanish commander at Pensacola sent a few soldiers to take possession of the bay and build a fort. Roldan, who led that force, found the French defenses in ruin, but he promptly restored it and made a survey of the vicinity at the end of the year 1718. In the following year re-enforcements came from Mexico under Don Gregorio de Salinas, to construct fortifications upon a larger scale at Saint Joseph's Bay, and soon afterwards the coast of the peninsula from Pensacola to Saint Augustine was explored. Thence onward, in the course of time, parts of the Gulf coast were visited by English, French, and Spaniards, and local settlements were founded.

In the year 1846 the United States Coast Survey commenced geodetic operations in the Gulf of Mexico, and in subsequent years latitude, longitude, and the magnetic elements have been determined at many stations. Tides and currents have been observed, and the configuration of the Gulf bottom is now as well known as that of the surface of any part of the adjacent territory. The geological structure of the Florida Reefs and Keys was investigated by the late Professor Louis Agassiz, whose report on the subject is given in the printed annual report of the survey for the year 1851. In other volumes will be found in detail the mention of developments made in the progress of the work on land and afloat.

Titles of copies of maps illustrating Dr. Kohl's history of the discovery and exploration of the Gulf of Mexico.

No.	Name of map.	Year.
1	Cuba and vicinity, with part of the east coast of North America, from Juan de la Cosa	1500
2	The Antilles, from the map of the world in the edition of Ptolemaeus, Rome	1508
3	The Antilles and parts of America, from a map of the world, in Ptolemaeus	1513
4	The Island of Cuba and vicinity, from the Globus of J. Schoener, Frankfort	1520
5	A map of the Mexican Gulf, from a Spanish map of the year ——	1520
	[NOTE.—This is the first map on which the name "La Florida" appears.]	
6	A Spanish map of the Mexican Gulf of the year	1521
7	The Mexican Gulf, from the map of the world by Diego Ribero	1529
8	The Mexican Gulf, from a French map by Nicolas Vaillard de Dieppe	1547
	[NOTE.—This is the first map on which the name of the Tortugas appears.]	
9	Copy of part of a manuscript chart preserved in Oxford, England	155?
	[NOTE.—Dr. Kohl states that this chart, which he thinks was made a little after or before the year 1550, is principally remarkable as being the first which contains a name for the Mexican Gulf—"Golfo Mexigo." This name, however, does not appear upon the part of the map copied by Dr. Kohl.]	
10	The Mexican Gulf, after a French map	155?
11	From a map made by J. Bellerus	1554
12	From a French map of the year	1556
13	From a map of Diego Homem, in the British Museum	1558
14	From a manuscript atlas of Juan Martines	1578
15	From a manuscript of John Dee, in the British Museum	1580
	[NOTE.—Dr. Kohl remarks, referring to a legend on this map, "Canalis Bahama versus Septentrionem semper fluit," that this appears to be the first map on which any notice at all is taken of the Gulf Stream.]	
16	From De Bry's map	1594
17	Florida and Appalachee, from Wytfliet	1597
18	Florida, by Herrera	1600
19	La Florido, by H. Chiaves	1601

Titles of copies of maps illustrating Dr. Kohl's history of the discovery and exploration of the Gulf of Mexico—Continued.

No.	Name of map.	Year.
20	Golfo de Nueva España, by Laet	1633
21	La Floride Espagñole, by Sanson d'Abbeville	1656
22	From a manuscript map of North America by J. B. Louis Franquelin	1688
	[NOTE.—On this map, as Dr. Kohl observes, the passes of the Mississippi and its delta are for the first time represented as projecting with many branches and islands into the Gulf.]	
23	From "Carte de la Louisiane et du Cours du Mississippi," by G. de l'Isle	1719
	[NOTE.—This map, published by the celebrated French geographer and academician, De l'Isle, under the auspices of the French Academy, is to be considered as the first carefully prepared scientific map of the regions bordering on the Gulf.]	
24	Carte de la Louisiane par le Sieur D'Anville	1732
	Dressée en Mai, 1732; publiée en 1752	1752
	[NOTE.—Dr. Kohl observes that this valuable map may be taken as the embodiment of all the knowledge and information which the French had acquired of the coasts, bays, and rivers east and west of the Mississippi in the year 1732.]	
25	Partie de la Costa de la Louisiane, by N. Bellin	1744
26	The Coast of Louisiane, by N. Bellin	1744
27	Carte reduite des Costas de la Louisiane et de la Floride par le Sieur Bellin, Ingenieur de la Marine	1764
28	Part of Texas, by Don José de Escandon	1747
	[NOTE.—With regard to this map Dr. Kohl remarks that it is one of the first on which the name of Texas appears as the name of a province.]	
29	A map of Florida, from the latest authorities, by Jefferys, geographer to His Majesty	1763
30	Parte del Seno Mexicano; from a Spanish manuscript map of the year	1765
31	Map of Florida, by Jefferys	1769
32	Map of the eastern part of the Gulf of Mexico, by B. Romans	1774
33	Carta Esferica del Seno Mexicano construida en el Deposito Hydrografico de Marina par Don Juan de Langara	1799
34	The Gulf of Mexico, after Humboldt, by J. B. Poirson	1811
	[NOTE.—Dr. Kohl remarks that these two last-named maps (Nos. 33 and 34) were for a long time the basis of all the maps of the Gulf. Humboldt gives an explanation of his map in his political essay on New Spain, French quarto edition, vol. I, p. 52.]	
35, 36	The descriptions of these two maps, as given by Dr. Kohl, do not correspond to the copies themselves in portfolio.	......
37	The Delta of the Mississippi, by le Sieur Divon	1725
38	The Mississippi Passes, by N. Bellin	1744
39	The Delta of the Mississippi, from a French Government map	1764
	Nos. 40 to 47 are sketches of the five principal harbors and bays of the Gulf of Mexico, as they are represented in the Spanish Portulano of 1818:	
40	Charlotte Harbor, by Romans	1774
41	Ponce de Leon Bay, by Romans	1774
42	Plan of the Bay of Pensacola, by N. Bellin	1774
43	Harbor of Pensacola	1818
44	Bay of Tampa	1818
45	Bay of Movila (Mobile)	1818
46	Bay of Galvez-Town	1818
47	Bay of S. Bernardo	1818
	[NOTE.—In addition to the maps above named, there is also on file in the archives a map compiled by Dr. Kohl, showing the progress of the discovery of the Gulf of Mexico, and indicating by colors the limits of the several explorers with the dates of their explorations.]	

ABSTRACT OF CONTENTS.

History of discovery and exploration on the Pacific coast of the United States.

California (1532).—Expedition sent out by Cortez, and commanded by Diego Hurtado Mendoza, for the exploration of the coast of California and islands adjacent.

California (1533–'34).—Second expedition fitted out by Cortes, and placed under command of Diego Becerra and Hernando de Grijalva.

California (1535–'36).—Expedition commanded by Cortes in person, reaches the coast of California. Lands at a port on the Gulf of California.

California (1539–'40).—Voyage of Ulloa to the Gulf of California under the general direction of Cortes. Other expeditions sent out by Mendozà, the successor of Cortes, under Coronado, Alarcon, Diaz, Cabrillo, and Ferrelo.

Sir Francis Drake (1579).—Reaches the Pacific coast in about latitude 48° on his voyage around the world. Sails southward along the coast in search of a harbor, and puts into "Drake's Bay."

Captain Thomas Cavendish (1587).—Makes a voyage to the Pacific, but reaches only the southern part of California.

Francisco Gali and Jayme Juan (1584).—The success of Sir Francis Drake induces the Spaniards to renew their northwestern explorations. Fleet fitted out by the archbishop and viceroy of Mexico to survey the northwestern coast of America. Voyage of Gali from the East Indies to the coast of California.

Sebastian Rodriguez Cermeñon (1595).—Accompanies an expedition to the California coast which results unfortunately, the vessel being wrecked in or near San Francisco Harbor.

Sebastian Vizcaino (1596–1603).—In the course of two voyages to California accomplishes a detailed reconnaissance of the coast as far north as Cape Mendocino.

New Mexico (1581–1611).—Explorations in New Mexico by Friar Augustin Ruiz, Antonio de Espejo, and by Juan de Oñate. Founding of Santa Fé.

Ferrer Moldonado and Juan de Fuca (1609–'25).—Reports of discoveries in the northwest and on the Pacific coast, not well authenticated.

Juan Iturbi, Francisco de Ortega and Estavan Carboneli (1632–'36).—Desultory expeditions to the California coast, contributing but little to the advance of geographical knowledge.

Don Luis Cestin de Canas, Don Pedro Porter y Casanata, Don Bernardo Bernal de Piñadero, Don Isidoro de Atondo (1642–'85).—Various attempts to continue examinations of the coasts of the Gulf of California and of the ocean shore. Also to found settlements at points suitable for harbors for the Manilla galleons.

Jesuit missionaries (1697–1717).—Explorations and settlements under the direction of the Jesuit Fathers, Juan Maria Salvatierra and Francisco Kino.

Father Jean Ugarte (1721).—Detailed exploration and partial surveys of the shores of the Gulf of California.

Father Sigismundo Taraval, Father Fernando Consak, Father Winceslaus Link (1732–'66).—Examinations of the Gulf of California and of the country adjacent continued by Jesuit missionaries until their expulsion from California in 1767.

Russian expeditions: Capt. Victus Bering, Capt. Tschirikow, Lieutenant Synd, Captain Krinitzyn, Lieutenant Levashoff (1728–'66).—Explorations in Bering's Strait and the waters in the vicinity; also of the Aleutian Islands. Occupation of the peninsula of Alaska; formation of trading establishments and of hunting stations.

French expeditions (1673–1750).—Reference to a number of expeditions under French auspices in search of the "Great River of the West."

M. Chappe d'Auteroche (1769).—Expedition under the auspices of the French Academy to California for the purpose of observing the Transit of Venus.

Franciscan Missions: Father Junipero Serra and others (1769–'74).—Establishment of mission stations by Franciscan friars at San Diego, San Buenaventura, and Monterey as bases for the gradual settlement of California by the Spaniards, and as centers from which exploring expeditions started to the northern parts of the country.

Sonora-San Diego (1775–'76).—Travels through the interior of California.

Father Francisco Garces, Don Juan Bautista de Anza, Don Bruno de Heceta, Don Juan Francisco de la Bodega, Don Juan de Ayala (1775).—Expedition from San Blas for the exploration of the northwest coast. First survey of the Bay of San Francisco. Highest latitude reached in fifty-eight degrees north.

San Francisco Bay (1775–'76).—Ayala's report of San Francisco Bay as a "cluster of harbors," with his plans and surveys, leads to further explorations and to the founding of the Presidio mission.

Don Fernando de Rivera Moncada, Don Felipe Neve (1776–'77).—Conducts a land expedition from Monterey northward. Crosses the plains of San Bernardino. Mission of Santa Clara founded.

Don Ignacio Arteaga, Don Juan de la Bodega (1779).—Expedition to the northwest, organized by the Spanish Court and by the Viceroy of Mexico, reaches the latitude of Mount St. Elias.

Don Fernando Rivera, Father Junipero Serra (1777–'84).—Establishment of additional mission stations on the coast of California between San Diego and San Francisco.

Capt. James Cook (1778).—Voyage to the northwest coast of America; touches at various points between Cape Gregory (now Cape Arago) and Nootka Sound. Great impulse given to other expeditions, both private and public, by Cook's voyages.

François Galoup de la Pérouse (1786).—Voyage to the northwest coast of America. Examination and survey of the coast from near Cape Flattery southward to the 45th parallel.

Captains Hanna, Dixon, Portlock, Berkeley, and others (1785–'87).—Commercial, trading, and exploring expeditions to the northwest coast. Some of these sent out by an association of London merchants, named the Nootka Sound Company.

Capt. John Meares (1788).—Explorations on the northwest coast in the vicinity of Fuca Strait, Cape Flattery, and to the southward.

Don Estavan Martinez, Don Gonzalo Lopez de Haro (1788–'89).—Examinations of Nootka Sound and the surrounding country. Explorations in the Strait of Fuca.

Don Francisco Eliza, Don Salvador Fidalgo (1789).—Expedition sent to Nootka to take possession of the island for the King of Spain.

Don Manuel Quimper (1790).—Sails from Nootka Island, passes along the southwestern shore of Vancouver Island, and examines the Canal de Haro.

Malaspina, Don Francisco Eliza (1791).—Voyage from Acapulco as far north as the latitude of Mount St. Elias. Accurate determinations of many points in latitude and longitude. Don F. Eliza, commander at Nootka, explores the Strait of Fuca and Rosario Strait and enters the Gulf of Georgia.

Marchand (1791).—Makes a voyage, partly for trading purposes and partly for exploration, to the northwest coast. Passes along the coast from Sitka Sound southeastwardly, and examines points of land, ports, and bays on Queen Charlotte's Island and in its vicinity.

Vancouver (1792–'95).—Makes three voyages of exploration and discovery to the northwest coast of America. Explores Admiralty Inlet and its branches; enters the Columbia River, &c.

American explorers: Captains Gray, Kendrick, and Ingraham (1788–'93).—Voyages to the northwest coast. Explorations in the vicinity of Vancouver's Island, Gray's Harbor, the Columbia River, &c.

Galiano and Valdez (1792).—Command the last but one of the Spanish expeditions to the North Pacific. Reach the southern point of Vancouver's Island, pass round the island, repeating the movements of the English explorer, and at length join Vancouver's party in completing the survey of the Gulf of Georgia.

Caamaño (1792).—Voyage of exploration to the North Pacific ordered by the Viceroy of Mexico. Passes round Queen Charlotte's Island, and makes observation on the shores of the neighboring continent, but adds little to the stock of geographical information.

Capt. W. R. Broughton (1795–'98).—Arrives at Nootka in 1796, and ascertains that the Spaniards had delivered the port to the English. Then proceeds southward.

Lewis and Clarke (1804–'06).—Are commissioned by President Jefferson to explore the Upper Missouri and find a practicable route of water communication with the Pacific. Having ascended the Missouri to the mouth of the Yellowstone, they cross the Rocky Mountains and trace the Columbia River to the ocean.

Russian expeditions (1803–'06).—Two vessels under command of Captain Von Krusenstern sail from St. Petersburg. Explorations made in northern parts of Russian America. Other explorations to the southward.

Fur companies (1806–'21).—Explorations made and trading posts established by the Northwest Fur Company, and the Missouri, the Pacific, and the Hudson Bay Fur Companies. And, under the auspices of the British Government, explorations made by Franklin, Richardson, Parry, and others.

Russian settlements (1812–'41).—Trading post and agricultural settlement established on Bodega Bay by the Russian Fur Company. Occupation of the Farallones, and of some of the islands in Santa Barbara Channel.

Missionary travels.—Reference to limited extent of explorations from the mission stations in California. No boats or vessels being available, land excursions were made yearly.

Capt. F. W. Beechy (1826–'27).—On returning from a voyage to Bering Strait, enters San Francisco Bay and completes a survey of the port. Makes a similar survey at Monterey Bay.

Sir Edward Belcher (1836–'42).—Commands an expedition to the Pacific coast organized by the Lords of the Admiralty, and extends surveying operations twice along that coast from Mount St. Elias to Cape San Lucas, including a survey of Columbia River to Fort Vancouver.

French explorations (1820–'42).—Reference to the resumption of French explorations on the Pacific coast; voyages of Du Petit Thouars (1837), La Place (1839), and Rosamel (1840); also to the diplomatic mission and journeys of M. Duflot de Mofras (1840–'42).

United States expeditions (1820–'47).—Travels and explorations in the far west by Long, Ashley, Smith, Bonneville, and others. Expedition under the command of William A. Slacum, U. S. N., explores the Columbia River. Map of the coast and country south of the mouth of that river compiled.

United States exploring expedition: Lieut. Charles Wilkes (1838–'41).—Fitting out of an expedition for exploring the South Sea and determining the position of Pacific islands, authorized by act of Congress. Sails in August, 1838, and arrives at Columbia River entrance in April, 1841. Makes examinations and surveys of the lower reaches of the Columbia River, of Gray's Harbor, the Strait of Fuca, Admiralty Inlet, and the Haro Archipelago; also of the Bay of San Francisco and Sacramento River.

Oregon and California.—Capt. J. C. Fremont (1842–'46).—Captain Fremont commands three expeditions through the interior of the continent. Is instructed by the Bureau of Topographical Engineers, on his second expedition, to connect his reconnaissance of 1842 with the surveys of Commander Wilkes on the Pacific coast. Carries a line of astronomical observations across the continent, reaching the Pacific coast on the northern shore of the Bay of Monterey. His map of Oregon and Upper California is published by the Senate in 1848.

Maj. W. H. Emory, United States Topographical Engineers (1846–'47).—Commands an expedition which starts from Fort Leavenworth, Kans., in 1846, and determines in geographical position one hundred and twenty stations between his point of departure and San Diego, Cal. Traces the southern boundary line of the United States, and fixes the nitial point on the Pacific coast.

United States Coast Survey (1848).—Preliminary arrangements made for beginning the survey of the Pacific coast. General reconnaissance, triangulation, astronomical observations, and hydrographic work provided for.

INTRODUCTION.

In September, 1513, Balboa, from the heights of Panama, discovered the Pacific Ocean; and in 1520, Magellan, sailing through the strait that bears his name, saw the same ocean at a more southern point. The record of these resolute men closes abruptly. Balboa was beheaded in 1514 by order of Pedro Arias de Avila, and Magellan was killed in a contest with savages at the Philippine Islands.

The immediate successors of the navigators just named occupied themselves more particularly with the western coast of South America, where they found the empire of Peru, supposed to be rich in gold, and no one thought of advancing northward until 1532, when Cortes turned attention to the northwest.

Thus for a period of forty years (1492–1532), during which the eastern and western coasts of South America had been circumnavigated, and imperfectly laid down on maps, and the eastern shore of North America explored by Spaniards, by English, and by the French, and the River St. Lawrence traced inland to a distance of 600 miles, one quarter of the coast remained unknown to Europeans. Large scope was left for the speculations of cosmographers and their views were wild and various. Some supposed that no continent existed, and that the lands found, as Florida, New France, Labrador, Greenland, &c., were only the extremities of large islands. As such they are represented on early maps. But, most men then living believed that North America was a large peninsula connected with Asia. Columbus himself so thought at one time. The land was supposed to stretch over into Asia from that part of Central America which was made known by Balboa and his successors, and by the first expeditions of Cortes; while Mexico, China, and Thibet, were represented as neighboring States. The Tartar nomads, with their herds of cattle, were supposed to wander in what we now call "The Buffalo Country," and the Empire of Japan was judged to be where California actually is. But, step by step, such notions gave place to views nearer the truth. In the course of two centuries, Japan, China, and the nomadic Tartars were gradually referred into place, and the great Pacific expanse between Asia and America widened to something like true proportion.

The prevailing notions of the time had great practical influence. Cortes and Mendoza sailed by charts erroneously constructed, just as Columbus had been guided by a map of the Italian, Toscanelli, when he discovered America. Expeditions intended for discovery along the northwestern coast were instituted merely because Japan and China were supposed to be in that neighborhood.

1532–1579.

In his third letter to the Emperor Charles V, Cortes states that Montezuma informed him that an ocean existed west of Mexico. Of the explorers sent out by the Spanish commander, some reached the Pacific in the neighborhood of Acapulco, at a point about 10 degrees northwest of the summit from which Balboa saw the ocean. Others went further in that direction to explore and conquer the kingdom of Mechoacan and Colima. The last brought back intelligence respecting an island rich in pearls and gold and inhabited only by a race of Amazons. The Indians of Mechoacan asserted that some of their tribe had visited the island and that it lay at a distance of ten days sail from Colima. Cortes relates this in his fourth letter to the Emperor, dated October 15, 1534; and it was probably the first notice received in Spain concerning California.

Cortes hoped to find a strait supposed to exist somewhere south of Yucatan, and in that direction he sent Captain Pedro Alvarado, who reached Guatemala in 1545. Thither were dispatched the first ships built by his order on the Pacific coast, and when he marched to Honduras it was to the same quarter that the steps of Cortes were turned. When of necessity his purposes in that direction were abandoned, active attention was turned to the northwest, but probably one reason for the change turned upon the fact that Nuño de Guzman, in 1530, conducted an expedition along the Saint Iago River, with a view of conquering the kingdom of Mechoacan.

The river then known as the Saint Iago is the largest in Mexico. It runs in a northwestern direction, and empties into the Pacific not far from the entrance of the Gulf of California, and this may be considered as the earliest embarkation of Spaniards for the northwest. Guzman was the

first who saw the coast opposite to the rocky peninsula of California. In his report to the Emperor he mentions a people said to be living at the west in a country surrounded by the ocean, and this intelligence, confirming previous rumors, probably gave rise to the maritime expeditions sent thither by Cortes two years afterwards.

CALIFORNIA, 1532.

The first expedition to that region was unfortunate and produced no result. It was commanded by Diego Hurtado Mendoza, a relative of Cortes, who with two ships sailed from Acapulco on the 30th of June, 1532. He was instructed to proceed northwest, explore the western coast of New Spain, and to discover, if possible, those "islands of the ocean," rich in pearls, and inhabited by Amazons, of which Cortes had been informed. This voyage may therefore be considered as the first Californian expedition, though it is doubtful whether Mendoza ever reached that country. But, pursuing the course indicated, he discovered several harbors, and the islands "las tres Marias," in latitude 27° 02′ N. When his provisions were much reduced his crew revolted, and he sent back one of his vessels with the sick and discontented. Nothing more is known of this unfortunate chief or of his companions. The returning ship was wrecked on its passage, and the few who survived that disaster were imprisoned by Nuño de Guzman, who was then governor of the northwestern coast of New Spain and the implacable enemy and rival of Cortes. The report of these misfortunes was all the information received by Cortes relative to the hapless experiment. Navarrete, in his introduction to the work entitled "Relacion del viage hecho par las Goletas, Sutil y Mexicana en el año de 1792. Madrid, 1802, page 11 et seq.," gives some particulars of this voyage.

CALIFORNIA, 1533–'34.

When Cortes heard of the loss of his vessels he resolved on a second attempt; and hastened to the harbor of Tehuantepec to hasten the outfit of the *Conception* and *San Lazaro*, which vessels he placed in charge of Diego Becerra and Hernando de Grijalva, with directions to pursue the course indicated for their predecessors; and at the same time to make diligent search for the missing captain Mendoza.

On the 30th of October, 1533, the two vessels sailed, but were separated by a storm on the second night of their voyage. Grijalva in the San Lazaro, anxious to rejoin his Chief Becerra, sought him in various directions. He went southward to 13° north latitude; and more than 100 leagues west of the coast of New Spain, an island was discovered and named Santo Tomas. One north of it he named Los Inocentes. These are now known as the *Revilla Gigedo Islands*.

Finding no trace of his commander, Grijalva returned, and was subsequently employed by Cortes in exploring other parts of the coast of New Spain. Meanwhile, Becerra, the chief of the expedition, seems to have pursued his course to the northwest, but not far. While yet on the coast of New Spain, he was murdered by his crew, who joined in a conspiracy against him under the chief pilot Fortun Ximenez. The pilot assumed command, reached the coast near the harbor now called La Paz, and as far as known was the first European who set foot on that soil. Soon after he was attacked by the natives and himself and twenty-two of his men were killed. The rest of the crew returned to New Spain, and at Xalisco were captured by Guzman and robbed. Little is known with certainty of the proceedings of Becerra and his pilot Ximenez. It is difficult to fix exactly the date of arrival of the first European vessel on the coast of California.

CALIFORNIA, 1535'–36.

The land reached by Fortun Ximenez was supposed by Cortes to be situated between Mexico and the Moluccas, and possibly in the neighborhood of the celebrated Spice Islands. Full of expectation, and desirous of searching again for his missing relative (Diego Hurtado) a new enterprise was planned, and Cortes determined to command it in person.

In hope of finding another country like Mexico, and also to be prepared against his hostile neighbor, Guzman, a force equal to that with which he had conquered Mexico was assembled by Cortes. The whole consisted of not less than four hundred Spaniards and three hundred negroes. This statement is cited by Navarrete from an old manuscript, and is given in his work at page 17.

On the point of embarkation a difficulty arose, that seems not to have been foreseen either by Cortes or his companions. The three vessels, namely, the Santa Aguida, San Lazaro, and Santo Thomas proved barely sufficient for the transportation of a third part of the company, encumbered as it of necessity was, with horses, canoes, implements, and provisions needful for war and for the settlement of a colony. Cortes, however, set sail from the harbor of Chiametlan on the 15th of April, 1535, bound for the place where the pilot Ximenez and his crew had been slain. Without difficulty the situation was identified.

On the 1st of May Cortes saw the mountains of California, and named them Las Sierras de San Felipe, and also an island, which he named Santiago. Two days after the party reached the desired haven, where the remains of the unfortunate Ximenes were still to be seen. The bay in which this port was situated they named Baia de Santa Cruz. In after years it was sometimes called the Bay of Cortes, and also the Bay of California. This last name, from whence derived we know not, was finally applied to the whole country.*

These few names, facts, and dates contain all the reliable information we have bearing upon the history of discovery. The remaining records of the expedition mention only shipwreck and disaster. It cannot be asserted that Cortes discovered any part of the coast north of the bay above mentioned; nor is it known how far north he went into the Californian gulf. He did not succeed in transporting the rest of his army and stores to California, though he made several attempts, and in person he at once returned to New Spain for that purpose. The ships dispatched by him generally failed to reach their destination; one with provisions arrived near the coast, and was beaten back to the disappointment of the men left on the peninsula, who suffered from hunger and disease, while the army marched hundreds of miles along the shore looking in vain for the lost vessels.

Cortes, ever active, encountered manifold perils and misfortunes on the gulf, which in his time was called the "Sea of Cortes," but was able to transport only a small supply of provisions from the coast of Mexico to relieve his famishing soldiers at the Bay of the Holy Cross. In the midst of these difficulties he was summoned to Mexico. The arrival of his successor, the Viceroy Don Antonio de Mendoza, and other affairs of importance made his return desirable; but unwilling to relinquish his Californian enterprise, and contemplating another expedition, Cortes left a small force under the command of Francisco Ulloa.

Meanwhile a report was circulated in Mexico that Cortes had been lost at sea on one of his voyages, and great anxiety was expressed for his safety. This, and a threatened insurrection of the Mexican Indians, induced the Viceroy, Mendoza, to send a vessel in search; and Donna Juana de Zuñiga, the wife of Cortes, in her extreme solicitude, dispatched ships for the same purpose. These were all met by the returning chieftain, who early in 1536 entered the harbor of Acapulco at the head of a fleet of six ships.

CALIFORNIA, 1539–'40.

Cortes, on his return to Mexico, found much to do. After settling his affairs with the new Viceroy, he was called upon to assist the Spaniards in Peru, who were then menaced by a general revolt of the Indians. The little force left at the Bay of Santa Cruz under the command of Francisco de Ulloa was in consequence withdrawn.

The decree which removed Cortes from the viceroyalty, constituted him "Admiral of the Pacific," with command of all the ports and naval force, and reserved to him the special right of discovery and conquest. Thus endowed for the prosecution of his purposes, he delegated the command to Ulloa, and on the 8th of July that officer sailed from Acapulco on what proved to be, as far as regards geographical discovery, the most important and successful of all the expeditions of Cortes.

A complete report of the voyage of Ulloa, written by Francisco Preciado, one of his pilots, was printed by Ramusio. Hakluyt translated it into English and inserted it in his "Third and last volume of the voyages, navigations, and discoveries of the English nation. London, 1600."

Ulloa coasted along the shores of Mexico, Sinaloa, and Sonora, and supposing the newly found

*Venegas Noticia de la California. Madrid, 1757.

California to be an island, sailed up the broad passage (Gulf of California), expecting to reach China or some other part of "India Superior," under which name was then comprehended the northeastern part of Asia. But to his disappointment he found fresh water at the head of the gulf, and the country around the Rio Colorado being then a low sandy plain, it was not easy to decide where the waters of the sea ended or those of the river began, or even to discern between land and water in the distance. From a small sand hill he could see only the river and an uninviting stretch of land, although some of the party were of the opinion that a narrow outlet could be traced leading to a sea beyond. The report of Ulloa left in doubt the real nature of the peninsula. Sir Francis Drake, in 1577, regarded it as an island.

From the head of the gulf, Ulloa coasted the eastern side of the peninsula of Lower California, and carefully examined each indentation, hoping to find a passage. At Cape San Lucas he turned to the west and examined the opposite shore. With adverse winds and currents he struggled northward and nearly reached the 28th parallel of latitude. Occasionally he landed; had encounters with the savages, and tried to convert his captives by baptism, and with ceremonies then customary he took possession of the region in the name of the King of Spain. In the course of the winter of 1539–'40, three attempts were made to advance northward and westward, but the vessels were always beaten back to the starting point. The most distant cape seen by the party was named by them Cabo Engaño (Cape Deceit), which is believed to have been a point or object visible near the 30th parallel of north latitude.

So much sickness prevailed amongst the companions of Ulloa that he was constrained at the end of March, 1540, to send back one of the vessels, the Santa Agueda, to Mexico with the invalids. That ship arrived without mishap at Acapulco with a report of the discoveries.

After repairing the Trinidad, which was the least damaged of his vessels, Ulloa remained on Cedros Island, intending to start from thence on a northwestern course, "convinced (he says) that this direction must bring him to something good and great"! His ultimate fate is unknown.

Cortes (the distinguished patron of Ulloa), who had manifested on these expeditions such energy, and spent large sums of money out of his private fortune, was destined to pursue them no further. He never returned to America after his departure for Spain in 1539.

The Viceroy, Mendoza, was thus left without a competitor in the broad field of adventure. Governor of Mexico and Admiral of the Pacific, he availed himself of his powerful position to become a promoter of the most important discoveries of the sixteenth century. Circumstances combined to induce Mendoza to pursue explorations in the course opened by Cortes. It was not, in his time, certain that the Gulf of California was closed at the north, and there was a lingering hope that it might afford a passage to China. That the nature of this gulf "should be brought thoroughly to light" was therefore an early subject of Mendoza's attention.

Some land travelers had reached the northwest and returned with accounts of the riches and advantages of the country. Of these the most noteworthy were Alvar Nuñez Cabeça de Vaca and the monk Marcos de Niza.

De Vaca, an officer in the unfortunate expedition which sailed from Xagua on the 20th of February, 1528, under Narvaez, had, in the course of nearly ten years, traversed the Gulf coast between Florida, from whence he set out, and some point west of the Delta of the Mississippi, and after roaming over mountains and plains had reached the shores of the Pacific in the year 1537.

Attracted by the relation of what De Vaca had seen in his wanderings and encouraged by Mendoza, the Franciscan monk, Marcos de Niza, in company with one of the companions of De Vaca, started on foot in March, 1538, for further explorations. But, even with the aid of his journal, the route traveled cannot be certainly made out, nor the localities identified that are in his report made the subject of romance and exaggeration. He asserted that he had been north of Mexico and that he had crossed a rich country and an empire called "Cibola," the metropolis of which was as large and brilliant as the city of Mexico. Before an altar erected in a lonely forest he secretly with some ceremony "took possession" of this empire and called it the "New Kingdom of San Francisco."

Niza moreover declared that he had discovered in the heart of the new world the fabulous "seven cities," so often sought in vain by the ancients amongst the islands of the Atlantic. Nothing was too improbable for the excited imaginations of his countrymen. They at once laid down

on maps, side by side, the famous kingdom of Cibola and the fabulous seven cities. Palaces roofed with silver and temples glittering with gold were items which adorned the descriptions in common discourse. After the return of the monk to Mexico, Venegas says (Noticia, pp. 163, 164) "Everybody in this city spoke of nothing but Cibola and the seven cities, and pretended that all the best things and the greatest riches of the world were to be found there."

The Governor of Guatimala, Don Pedro Alvarado, as well as the Viceroy of Mexico, now began to prepare new expeditions for this field of research. Captain Burney in his History of Discovery in the South Sea; London, 1803, vol. 1, page 193, says that the return of the monk Niza and his exciting narration stirred up Cortes and gave rise also to the expedition of Ulloa, which he therefore relates after Niza's report. This is doubtless a mistake. Niza left Culiacan in March, 1539 (the date given by Burney on page 189), and after wandering a year at the north he could not have returned to Mexico before the beginning of 1540. Ulloa sailed early in July, 1539, and so Captain Burney states on page 194. His voyage, therefore, should have been recounted before that of Niza, and cannot be reasonably considered as a consequence of that expedition. The same error has been repeated by subsequent writers.

Alvarado collected a fleet, and made an agreement with Mendoza to combine their forces for discovery and conquest in the northwest. The armament was to be under the command of Alvarado, but the sudden death of that officer in 1541 stopped the undertaking, and the fleet was dispersed.

Mendoza had meanwhile completed the array of a military force designed to follow the track of the monk Niza and conquer the kingdom of Cibola, and to "explore the secrets" of the Gulf of California. This expedition consisted of two divisions, one to proceed by land the other by sea. Francisco Vasquez de Coronado, Governor of the northwestern province of New Galicia, was placed at the head of the former, with orders to march through Sinaloa and Sonora, while Hernando de Alarcon, in command of the marine force, should sail along the shores. Both companies set out at the same time in the spring of 1540, and their departure was coincident with the return of Ulloa's men from the west.

Alarcon, who sailed from Acapulco on the 9th of May with the ships San Pedro and Santa Catalina, completed and extended the discoveries made by Ulloa at the north of the Gulf of California. "Because [he writes to Mendoza] your highness has commanded me to bring you, at all events, the mystery of this gulf, I determined not to leave until I had thoroughly explored the innermost recesses of its waters." He therefore entered the river which Ulloa had only seen afar off, and sailed up its stream in boats for fifteen days, always hoping to find the rich "kingdom of Cibola" and to meet Coronado, with whom he was to co-operate.

Disappointed in both of his objects, Alarcon returned to his ships, which lay at the mouth of the Sacramento, after having traversed 85 leagues of the course of the river with great difficulty. Near the entrance he erected a chapel in honor of the "Señora de la buena Guia" (our lady of the Good Guide), and called the country "La Campaña de la Cruz."

Alarcon discovered also the mouth of the river Gila, a great branch of the Colorado, and named it Brazo de Miraflores. He remarks that the "men of the marques," alluding to Francisco de Ulloa, were mistaken in fixing the latitude of the head of the Californian gulf, placing it 2 degrees too far north, and that he had himself been 4 degrees further in that direction than any who preceded him. At the end of the year 1540 Alarcon returned to Mexico.

Coronado was meanwhile engaged in his land journey. Until the year 1838 nothing had been published concerning his expedition, excepting the short report in Ramusio's Vol. III, and occasional allusions to it in Herrera and Gomara. At that time, however, M. Ternaux Compans gave to the public a full account, written by Pedro de Castaneda de Nagera, one of the companions of Coronado.

In April, 1540, Coronado set out from Culiacan, then the most northern Spanish town in Mexico, and the depot of land expeditions, as Acapulco was for those by sea. His army consisted of above six hundred Spaniards and many Indians, besides a number of enterprising young noblemen, the flower of Spanish chivalry in Mexico. The array is mentioned by old writers as one of the most complete and brilliant of the time.

With this imposing retinue Coronado took his course through the country east of the Cali-

fornian gulf. At a considerable river, which they called Rio Tizon, they turned towards its head "and traversed promising countries and some deserts." The route of the army can be approximately traced. It is evident that the course was in the vicinity of the Gila and across the valley of the Rio Bravo towards the plains east of the Rocky Mountains. The buffalo hunts, the geographical features of the plains of the Upper Arkansas and Red Rivers, their extent and barren nature, even the long deep crevices into which the buffaloes as well as the horses of Coronado sometimes fell headlong, are so minutely described by Castaneda, that there can be no doubt in regard to the region crossed by this party.

Castaneda observes that the rivers which they saw probably emptied into the great river Espiritu Santo, discovered by De Soto; that is, into the Mississippi. Early in April, 1543, the army retraced its course, and reached Mexico at the end of the summer.

"Our enterprise" says Castaneda, "took a wrong course. We looked for Quivira on the desert plains of the northeast, but the rich Quivira or Great India lies toward the northwest. This is now quite clear from the sea expedition of Villalobos, who examined the coast of the Pacific and found Great India in that direction."

Some early writers mention Quivira as bounded by the Pacific, and assert that Coronado's company saw strange ships having on their prows images of birds wrought in gold and silver, and laden with merchandise supposed to have been brought from China. Castaneda says that the vessels so ornamented were only canoes, and that he was so informed by the Indians who assured him that they were common on a certain river in the interior. Gomara erroneously judged that the water mentioned might be the western ocean, and from that time "Quivira" was marked on nearly all contemporaneous maps in the position occupied by San Francisco Bay. On some maps it is marked as being north of that bay.

Cabrillo, sailing along the coast in the autum, of 1542, was repeatedly told by the savages that other Spaniards were traveling in the interior, and with these he tried to put himself in communication. He heard of them for the last time at Juan de Capistrano. It was reasonable to suppose that the party were Coronado and his followers. Castaneda says that the Knight Melchoir Diaz, with a number of men, penetrated beyond the Colorado River. According to that writer, Diaz was left by Coronado in charge of a fortified station on the route, but full of the spirit of adventure he delegated the command of the quiet station, and set off at the head of twenty-five chosen men for exploration towards the coast. After reaching the Rio Tizon he traveled along the southern bank. Indians told him of the ships of Alarcon, and showed him the place of embarkation, where Diaz found a tree with the inscription: "Alarcon came as far as this place; there are letters underneath." From the letters Diaz learned that the sea of Cortes was an inclosed gulf, and that Alarcon, after some time waiting the arrival of Coronado, had returned to Mexico.

The Knight Melchoir Diaz crossed the Colorado on rafts constructed with the help of Indians, and struck into the interior of what is now known as the Colorado Desert. How far the party advanced before reaching that desolate region is not known. They describe it as being "covered with hot ashes that seemed here and there to boil in fierce agitation." The ground trembled under their feet, and the aspect of the place was forbidding. They found no water and turned for the starting point. On the route Diaz was killed by an unfortunate accident.

Expeditions to the sea of Cortes were no longer thought of. Ulloa as well as Alarcon had reported it landlocked; no doubt remained, and it is represented as a gulf on all the charts of the sixteenth century.

The next party sent out by Mendoza proceeded therefore to the outside of the peninsula.

Two vessels, the San Salvador and La Victoria, under command of the Portuguese pilot Juan Rodriguez Cabrillo, left the port of Navidad, Mexico, on the 27th of June, 1542, and sailed along the coast as far as it had been previously explored by Ulloa; that is, to the Isle of Cedros and Cabo Engano where they arrived on the 20th of August. From thence, advancing more successfully than their predecessors, against adverse winds and currents, Cabrillo reached higher latitudes. At 34° north he saw not far from the coast an inconsiderable group of desert islands (unas islas desiertas), and near them a harbor, which he called Puerto de San Miguel. The islands are now known as "The Coronados," and the port was doubtless San Diego. The latitudes assigned by the Spaniard

for these places are not correct, but in every instance (excepting at Cape San Lucas) the latitudes of Cabrillo are in error about a degree and a half.

On the 7th of October Cabrillo saw two islands, which he named after his vessels San Salvador and La Victoria. They are now called San Clemente and Santa Catalina. Beyond these he entered a bay to which he gave the name of Baia de Fumos, perhaps the same that is now known as San Pedro Bay, and passing several other islands on the way, he sailed through what is at present designated the Santa Barbara Channel; Point Conception was named by him Cabo de Galera, and was placed more than a degree and a half too far northward. Stormy weather delayed progress, and at length drove him some distance southward, where he discovered an island which he named San Lucas. The island is now called San Bernardo. A harbor eastward of the cape gave his party shelter, and received the appellation of Todos Santos (San Luis Obispo), and another, that of Puerto de las Sardinas, which is perhaps the place now known as San Simeon. Cabrillo finally doubled the cape and along the coast made careful search, says Herrera, "for the Rio de Nuestra Señora, which, however, they could not find."

At 37½° north latitude, according to Cabrillo, a range of lofty mountains was in view, probably the Californian coast range, named by him Sierra de Saint Martin. On the 17th of November the voyagers entered a bay, supposed to be the Bay of Monterey. They called it Bahia de los Pinos. In latitude 38° 40′ of their reckoning (about 37° north in reality) they saw a projecting spit of land, to which they gave the name Cabo de la Nieve—the snow cape. That cape is supposed to be Punta año Nuevo.

In a storm which separated the two ships for several days Cabrillo was carried considerably northward, and saw, at a distance, another cape (probably Point Arena), and that was the highest latitude attained by the party. Sickness, conjoined with cold and stormy weather, induced him to return as far south as the island of San Lucas (San Bernardo), where he had found a tolerably good harbor. This he reached on the 23d of November, 1542, but Cabrillo soon after fell sick. He died on the 3d of January, 1543, leaving the command of the expedition to his first pilot Bartolomé Ferrelo, or Ferrer.

Ferrelo and his companions soon felt the want of provisions, and on the 19th of January they left the harbor to search for provisions and wood. In stormy weather, which was continuous, they touched at several points on the main, and at the Santa Barbara Islands, but finally retired to their winter quarters. In a second attempt at sea they were carried far to the southwest, where they discovered "some other desert islands, great and small." These were doubtless the Sandwich Islands. Still harassed by tempests the vessels were turned north, intending to make for the Bay of Monterey, but were carried beyond it—Herrera says to the 44th parallel of north latitude, where they saw the mouth of a large river. This was the highest latitude reached by Ferrelo. Storms were frequent, and the cold was excessive. He was thus forced to turn to the southward. Some of his company died; others were ill, and the able-bodied were on the point of starvation, "only a scanty supply of spoilt biscuit" remained. Thus crippled, he returned to Mexico with the remnant of his party.

There has been some difference of opinion with regard to the latitude reached by this expedition. If the 44° north, quoted by Herrera (probably from the journals of Cabrillo and Ferrelo), was actually observed by them, and if it is true, as asserted by Navarrete, that they were always in error by one degree and a half, it is fair to conclude that 42½° north latitude was the limit in latitude.

Ferrelo, on his homeward passage, probably saw Cape Mendocino. That name does not appear in his report, but the position corresponds with that of a headland which he named "Cabo de Fortunas."

Nothing in the history of these voyages as drawn from the reports of Cabrillo and Ferrelo indicates that either of those navigators entered the Bay of San Francisco, though they seem to have passed near its entrance several times. They certainly had no knowledge whatever of the great harbor to which the opening at the Golden Gate conducted.

Ferrelo reached Mexico with both of his ships after a passage of six weeks along the coast of California. On the first of March he was on the northern limit of his voyage, and on the 14th of April he entered the port of Navidad.

With the exception of Alarcon, all the chiefs of naval expeditions sent to California by Cortes and Mendoza had died or were lost at sea in the voyages. Only remnants of their parties returned with appalling accounts of storms and dangers encountered in frozen regions and on desert coasts. It is therefore no wonder that zeal for California exploration lessened, and that a long pause ensued unmarked by any similar attempt; that "*the north is cold, rough, and poor*" became an adage amongst Spaniards; and their horror of that region was deepened by the return of a remnant of De Soto's expedition in the same year with that of Ferrelo, 1543. The sufferers who survived the hardships of travel came back from the interior after seeking vainly for three years the fabulous Quivira, as others had sought an ever-receding Eldorado.

Such failures, of course, checked the fervor of discovery. Riches and employment nearer home were offered by the silver mines of Mexico, which disclosed abundant treasure, and at length attention was drawn to the advantage of settling and improving territory instead of merely plundering it. It was the avaricious spirit of the age that sent Cabrillo, Coronado, and De Soto so far to the north. When we consider that the Spaniards had in their earlier enterprises reached the fortieth parallel of latitude on the eastern coast, it may be said that in abandoning expeditions on the Pacific coast they relinquished North America; not only the shores but also the interior. But, considering the imperfect state of the art of navigation in the period here under review, it is remarkable that so much was accomplished in the way of geographical development. Moreover, fortune at the same period beckoned over quiet seas with favoring breezes toward the coast of Asia. Instead of heavy gales and a tempestuous ocean, the trade-winds invited navigators to the east. Cortes, the conqueror of Mexico, had sent out expeditions to the Old World, and Mendoza had also dispatched one under Villalobos in the year 1542, and when, soon after the middle of the century, the Philippine Islands were acquired by Miguel de Legaspi, a lucrative commerce was established between Mexico and Asia, the respective ports being Acapulco and Manilla.

Many vessels sent westward from New Spain had attempted to return over the broad Pacific, but without success. Sailing too far south in latitude the trade-winds were against them, and it was not until the time of Legaspi's expedition that the prevalence of winds north of the tropics was discovered. The first vessel that took advantage of these winds for returning from Asia to New Spain appears to have been the San Lucas, one of Legaspi's fleet, that deserted him in consequence of the disaffection of the captain and pilots. From Mindanas that ship kept a northerly course, and reached the American coast near Cape Mendocino, and from thence coasting along California arrived at New Spain. Of the same fleet another vessel, le Capitano San Pedro, took that course from the Philippine Islands under command of Father Andres de Urdaneta, who carefully kept a journal, made observations, and gave the results on a chart which served as a guide in subsequent voyages.

Somewhat above the 40th parallel Urdaneta had met the northwest winds, and sailed with them, as the San Lucas had done along the coast of California to the shores of New Spain, where he arrived three months later. Burney says that the chart of the Northern Pacific by Urdaneta was in use among Spaniards in 1623.

Soon after the discovery of this route a regular and profitable intercourse was organized between Mexico and Asia; and there is little doubt that this circumstance turned the tide of Spanish navigation again into its usual direction from east to west. Hence these excursions to the north may be considered as exceptional deviations. Amongst other causes conjoining to this result was the progress of the Portuguese in the northeast part of Asia. They had reached China as early as 1530, and probably visited Japan a few years after.

In the latter part of the sixteenth century there was apparently a pause in the march of enterprise at the north and at the south. California and Chili were no longer arenas of research, and some discoveries of early date were forgotten. Some even questioned the existence of the Strait of Magellan. The Spaniards at that time were in quiet possession of the Pacific Ocean as a great highway for richly laden galeons that passed from the New World to the Old, gathering the wealth of both, and they feared lest their advantage might be lost. When, therefore, Sir Francis Drake entered the Pacific Ocean the Spaniards were aroused as by a thunderstroke.

The interval between Cabrillo's expedition and the renewed spirit of adventure was, as usual in such cases, filled with fabulous tales of impossible voyages. Some instances will be mentioned:

A Portuguese sailor, named Martin Chacke or Chaque, was said to have sailed in 1555 from the Atlantic to the Pacific Ocean at the north of California, and to have reached the western waters in latitude 59 degrees north.

Andres de Urdaneta, before alluded to, a mariner well known in Spain, was reported to have gone from the South Sea to the Atlantic in 1556,-'57, circumnavigating the countries called California and Florida; and another Spaniard, Juan Fernandez de Ladrillero, in 1574, pretended that he had certain knowledge of the existence of a passage north of California and Florida; that he had been at the entrance of the strait, and could have easily gone through it if the condition of his ship had not forced him to return home. These reports are not worthy of critical inquiry as to their origin and history, having but slight relation to the coasts with which we are now concerned. Navarrete gives, for the curious, ample details in regard to the spurious reports.

SIR FRANCIS DRAKE, 1579.

English and French seamen and privateers had for more than half a century contented themselves with plundering Spanish colonies on the eastern side of America, but at length a bold adventurer extended his system of war and pillage into the Pacific.

Drake fitted out, partly at his own cost and partly by the aid of private gentlemen and companies, a fleet of five small vessels. At the outset his flag-ship was named The Pelican, and the commander was, in a certain sense, commissioned by Queen Elizabeth. The expedition left England in December, 1577, sailed on the track of Magellan, and passed through the strait named after that navigator. There Drake changed the name of his principal ship, calling it The Golden Hind, and towards the end of 1578, with only two other vessels in company, he entered the South Pacific Ocean. Soon after the two vessels separated from the flag-ship, and Drake continued the voyage alone in The Golden Hind.

In the spring of 1579 he sailed along the western coast of South and Central America, capturing and burning Spanish ships, and plundering some of the Spanish settlements. Laden with spoil, his vessel at length reached the harbor of Guatulco, but again put to sea on the 16th of April, steering boldly into the Pacific on a course west and northwest for 1,400 leagues without seeing any land. His probable intention was to circumnavigate the continent of North America and return eastward to Europe. Such design is not stated in the account of Drake's voyage, but the opinion then generally held, that America could be circumnavigated through an open sea or strait at the north, as it had been at the south, strengthens the probability of the supposition. Geographers of that period gave to the supposed channel at the north the name "Strait Anian," and under that name it is depicted on all the maps of the next two centuries, with outlines as distinct as if they had been actually surveyed. Frobisher had shortly before discovered the strait which bears his name, and thus in England the hope of finding a northern passage had become very strong. Without doubt the expectation of Drake was to reach Frobisher's strait from the west, and so avoid a long and dangerous voyage in coming home by the Strait of Magellan. Apparently with this intention he held on west and northwest, turning gradually eastward. The season and other circumstances of his passage seem to have been favorable until he reached the forty-second parallel of north latitude. There he encountered strong northwesterly winds and extremely cold weather, but turned his ship to the northward and eastward, and holding that course discovered the coast of North America in latitude 48 degrees north. At this point The Golden Hind anchored for some time in an open, illy-sheltered bay. It is a disputed point whether or not Drake reached the forty-eighth parallel as stated in The World Encompassed, or only 43 degrees, as given in Hakluyt's report of The Famous Voyage. The best English and other foreign authorities admit 48 degrees north latitude as Drake's northern limit.

The weather continued unfavorable; thick fogs prevailed, followed by a northeast storm in which the crew suffered much hardship and were greatly discouraged. Finally the extreme cold and recurring storms from the northwest obliged the commander to desist from his search for the supposed passage eastward, and the unbroken character of the coast which he had traversed

probably hastened his determination. He concluded that the coast, instead of turning eastward, "ran directly into Asia," and hence he resolved to sail for England by way of the Cape of Good Hope. With that intention he went southward to find a harbor on the coast of California in which his men might recruit their strength and repair the damaged vessel for such a voyage. In latitude about 38 degrees north he found the desired haven, and piously attributed its discovery to Divine Providence, which he declares had also favored him with a good wind for entering in safety. Here Drake passed nearly five weeks in repairing The Golden Hind, recreating his men, and exploring the surrounding country. The harbor which afforded the needful shelter was very probably that small bay that since Vancouver's time has been called Sir Francis Drake's Bay. The adjacent country was found "very pleasant, full of goodly plants, trees, and deer, of which (he says) sometimes thousands range in one herd."

It is remarkable that even the golden treasures of that region did not escape observation. In his report Drake says: "There is no part of earth here to be taken up wherein there is not some special likelihood of gold or silver;" but that sentence, though often reprinted and read by thousands, seems to have been overlooked or disregarded. Drake's intercourse with the natives was peaceful and cordial to such a degree that "they made him their king, and crowned him as such." He is generally regarded as the first European visitor on the territory of California and Oregon, though he was preceded in discovery at least as far as the forty-third parallel by Cabrillo and Ferrelo. He named the country "New Albion," because the cliffs on the coast appeared to him like those of Southern England. That name was retained on all European maps except those compiled in Spain for nearly two centuries.

On the 23d of July Drake left the harbor, and the day following fell in with several small islands, on which his men passed some hours in catching seals and birds. This group he named "The Islands of Saint James," subsequently the Spaniards called them "Los Farallones." Drake then sailed westward in pursuance of his design of returning to Europe by way of the Cape of Good Hope, and on the 26th of September, 1580, arrived in England, where he was hailed as the first circumnavigator of the globe. No immediate successor followed in this career.

Capt. Thomas Cavendish in 1587 made a voyage to the Pacific, but reached only the southern part of California, and recorded nothing new in the way of discovery. With this exception an interval of two hundred years passed (1579–1778), during which no English navigator appeared on the northwestern coast of America.

The next in enterprise and discovery was Capt. James Cook, and until his time the name of Drake, his harbor, his New Albion, and discoveries on the northwestern coast of America were freely mentioned by writers on geography.

FRANCISCO GALI AND JAYME JUAN, 1584.

Activity was awakened by the inroad of the English into the Pacific, and the Strait of Magellan became a prime object of attention to the Spaniards. The governors of Chili and Peru, wishing to shut that pass against the English, organized expeditions for the purpose, and tried to construct forts there. Similar measures at the northwest did not seem urgent, as no intruders, to their knowledge, had found entrance or exit in that direction. This fancied security lasted until it became known to the Spaniards in Mexico that Drake had visited and given the name of "New Albion" to a region far in the north. They heard, moreover, that the English were seeking from thence the "Strait of Anian," the discovery of which had been several times proclaimed. Fears of what might result finally induced the Spaniards to renew their northwestern explorations. As before mentioned, these had ceased with the voyages of Cabrillo and Ferrelo.

In the year 1584 Don Pedro Moya de Contreras, then Archbishop and Viceroy of Mexico, fitted out a fleet under command of Capt. Jayme Juan, with orders to survey the northwestern coast of America. A special object in this intended expedition was to effect some settlement on the coast of California, and to erect fortifications "for the benefit of Spanish ships returning from Asia."

After the year 1564 the Acapulco and Manilla galleons regularly sailed to the Philippine Islands by a southern route, taking advantage of the trade winds. Their return voyages were

made in a higher latitude, with variable winds, towards the shores of California, where northwest gales and predominant currents aided in the passage to Mexico. These Manilla galleons were the only Spanish ships that touched along the northwestern coast, and, so to speak, they had in that casual way kept some knowledge respecting it. For their safety in returning it was essential that the coast should be better known, and that some settlement, and, if possible, harbors for shelter should be established. As before stated, such an undertaking had been determined upon in 1584.

While the viceroy, Contreras, was preparing in the harbor of Acapulco the expedition for that purpose, a vessel from Asia arrived there under command of the able and enterprising pilot Francisco Gali. He was believed to have seen more of the northern parts of the Pacific Ocean, including the coast of Northeastern Asia as well as that of Northwestern America, than any one of his predecessors. Hence his voyage enlisted much attention, and though mainly intended for trade it ranked amongst enterprises for discovery.

Information in regard to Gali's voyage is contained in the work of Juan Hugues de Linschoten, "Reise-geschrift von de navigation der Portugaloisers in orienten," which was translated into English in 1598, and published by T. Wolfe in London. Linschoten says that the report which he gives of Gali's voyage was translated from the original Spanish into Low Dutch. Hakluyt reprinted in his third volume, in 1600, the English translation of Wolfe.

Gali had sailed in the year 1582 from Acapulco to Manilla, and from thence to Macao. Leaving the latter port on the 24th of July, 1584, he returned by way of Japan, of which Empire he believed he had seen the northeastern extremity, and then stretched his course over the Pacific Ocean, in a direction "east and northeast" towards America. The point where he reached the coast has been a matter of doubt. Navarrete and some others state the latitude as 57½ degrees north; but the English historians of the South Sea, Burney, Travers, Twiss, and others, assign the lower parallel of 37½ degrees. This last appears most probable, as it is supported by the Dutch report of Linschoten, by the translation of Hakluyt, and by the subsequent editions of his report. The version 57½ degrees north occurs first in a French translation of Linschoten, entitled "Le Grand Routier de mer. Amsterdam, 1638," and is probably a misprint.

Gali states that he saw on the coast a beautiful country covered with forests and entirely without snow. Sailing, as he did, from Macao, at the end of July, he probably reached the coast of America late in October, and at that time of the year he would no doubt have found Mount Edgecumbe, nearest to which Navarrete supposes him to have touched, covered with snow.

This voyage was a trading expedition. With Gali, discovery was incidental. His report does not refer to a northwest passage. The object was, with ship and goods, to reach New Spain without delay. Nothing but irresistible necessity, due to storms, could have driven him so far out of his course. He seems to have followed the usual track of Manilla vessels, perhaps a little farther to the northward.

The expedition then preparing at Acapulco, being destined for the region so recently visited by Gali, the viceroy consulted that navigator in regard to it, and the report of his voyage seems to have been drawn in response. This was accompanied by a map giving latitudes and longitudes.

How far the preparations of Contreras had then advanced is not exactly known; probably not far, as in a letter to the King of Spain, dated March 24, 1585, he alludes to his "intentions," and solicits the royal sanction and support. However, the viceroy was superseded in his government at the end of the year.

SEBASTIAN RODRIGUEZ CERMEÑON, 1595.

It has been already mentioned that the English adventurer Cavendish, had, like Drake, made his way to the coast of California. In emulation of the last-named commander, Cavendish captured the Santa Anna, one of the richest of the Manilla galleons. This was in November, 1587. The loss, when made known in Spain, suggested the expediency of sending out their vessels, intended for California, from the Philippine Islands, rather than from Mexico, because the prevailing winds would in that case be favorable.

Don Luis Velasco, Viceroy of New Spain from 1590 to 1595, accordingly issued instructions for testing the route. It is probable that Gomez Perez de la Mariñas, to whom that service was

intrusted, used one of the regular Manilla galleons, as the vessel (The S. Augustin), besides being commissioned to make discoveries, was laden with silks and other oriental goods destined for Mexico. Navarrete says that this ship was specially commissioned to examine the "port of San Francisco" and its vicinity. So far as we know, this is the first mention of a port with that name. The adventure was extremely unfortunate. Cermeñon reached the coast of California, but his vessel was wrecked in the immediate vicinity of a large harbor, called by Torquemada, the historian of the expedition, Puerto de San Francisco. The ship, the goods, and the greater part of the crew were lost. Some of the men found their way back to Mexico, and amongst them Francisco de Volaños (called "Pilote Mayor"), who gave information of the disaster, and afterwards (in 1603) accompanied Viscaino to the place where it occurred. From some accounts it seems that the vessel was stranded inside of the bay; but the Spanish pilot, Cabrera Bueno, in his sailing directions (Dalrymple, p. 48), seems to indicate the Farallones, but adds, that "the loss was due more to the fault of those on board than to stress of weather." What is known of this interesting expedition is stated by Torquemada. Argensola does not mention it in his history of the Philippine Islands. The San Augustin is said to have foundered "in the port of San Francisco." The Spanish pilot says: "In the port of San Francisco, on the islands of Farallones"!

Some have thought that the "Puerto de San Francisco" of Torquemada was our Bay of San Francisco, but it is more probable that he applied the name, as the pilot, Bueno, evidently did, to the waters south of Point Reyes, east of the Farallones, and off the Golden Gate. Subsequent statements seem to prove that neither they nor Volaños had any knowledge of the landlocked bay now bearing that name.

SEBASTIAN VIZCAINO, 1596.

The wreck of the San Augustin made evident the necessity for a settlement on the coast of California, and preparations to that end were ordered by Philip II, to carry out the plans of the viceroy, Contreras. Soldiers, sailors, and laborers were recruited, and three vessels were fitted out with requisites for a settlement. Some women were also embarked. The expedition was placed in charge of the very enterprising pilot, Vizcaino. The principal authorities for particulars respecting this expedition are Torquemada "Monarquia Indiana," and Navarrete, who used some manuscripts ("algunos documentos manuscriptos") which he does not further describe.

This expedition sailed from Acapulco in the beginning of the year 1596 and was in all respects ineffectual. Vizcaino spent his time, provisions, and means in an abortive attempt to found a settlement on the rocky coast of the Californian peninsula; but finding his ships and their crews no longer in a condition to pursue discoveries, he returned at the end of the year. The only result was merely the change of a name. The bay known in the time of Cortes as Santa Cruz was subsequently called La Paz.

Some delay in Californian research followed the death of Philip II; but in 1599 his successor, Philip III, sent orders to the count of Monterey, Viceroy of Mexico, to make arrangements for an expedition to the northwest. Monterey decided to employ Vizcaino, who was then supposed to have more knowledge of the coasts of New Spain than any other commander. On his second voyage he set out from Acapulco on the 5th of May, 1602. The principal sources of information respecting it are the following:

1. The original journal kept by the Carmelite monk, Father Antonio de la Ascension, who accompanied the expedition. Venegas says in his Noticia, volume III, page 23, that he sought in vain in the archives of Seville for the original journal of Vizcaino's voyage. Navarrete says (page lxviii) that he found there a copy of the original, which original had been left for preservation in Mexico.

2. A report of the voyage by Torquemada in his "Monarquia Indiana," lib. 5, cap. 45. This writer had access to the journal of Father Antonio, or had a copy, from which he made extracts. But as the report itself was never printed, Torquemada was for upwards of two centuries the only authority in regard to the particulars of the voyage. When his work (printed in 1615, and again in 1725) became rare, Venegas reprinted it (in 1757) in his "Noticia de la California."

3. Navarrete, who, in addition to the original report of Father Antonio, used other manuscript documents, accessible only to himself. He names the following:

(*a.*) The agreements and opinions of the councils and meetings of Vizcaino's officers held in the course of the voyage.

(*b.*) The Routier of navigation along the coast of California, made by the cosmographer, Geronimo Martin Palacios, who accompanied the expedition.

(*c.*) Thirty-two charts and plans of the coast, showing ports, inlets, &c., made by Enrico Martinez, cosmographer of the King, in New Spain. Navarrete compiled from them a general chart. He used other documents, but does not specify in regard to them.

With greater facilities than either of his predecessors, Vizcaino surveyed more accurately the coast line of California from Cape San Lucas northwestward to beyond Cape Mendocino, beyond which limit he was not authorized to go. That headland was the point for which the Manilla vessels on their home voyages usually made; and north of it they never sailed.

Vizcaino had with him experienced officers, amongst whom were Volanos, the surviving pilot of the San Augustin, and a distinguished cosmographer, Geronimo Martin, who was commissioned to draw the maps and charts of the expedition.

The fleet commanded by Vizcaino consisted of two large ships, the Capitana San Diego and the Fregata Tres Reyes, which last was accompanied by a small tender, the Santa Tomas, for navigation in shoal water. He had also a long bark (un barco luengo) for entering inlets, rivers, and creeks, but that craft proving to be an incumbrance was abandoned near Cape San Lucas.

During the first six months the party was employed in carefully examining the western coast of Lower California. They discovered, named, and surveyed a number of bays, as Magdalena, Santa Marina, Ballenas, San Bartholomé, Simon and Judas, and Todos los Santos. Off the southern extremity of the coast, where they arrived early in November, four small islands were discovered, to which they gave the name "de los Coronados."

On the 10th of the same month the little fleet entered a harbor north of the Coronados, which harbor, sixty years earlier, Cabrillo had named San Miguel; Vizcaino gave it the name of San Diego de Alcada, probably in honor of the holiday which falls on the 12th of November, and perhaps, also, to commemorate the name of his flagship. With the two exceptions (Point Pinos and Cape Mendocino), no geographical name given by Cabrillo has been retained. Hence it may be inferred that Vizcaino* was not acquainted with Cabrillo's reports nor guided by his maps.

After providing wood and water Vizcaino sailed on the 20th of November. On the 27th they had in sight a large island, which they named Santa Catalina, as first seen on St. Catharine's day. It was found to be densely populated. After mapping the island the voyagers kept on southward and reached the island now known as San Clemente, the survey of which was deferred and not finally accomplished. Hence it received no name at the time, and is not marked on the chart of Vizcaino.

On the evening of Santa Barbara's day (3d of December) the party was at the eastern end of a chain of islands between which and the coast of California lay a broad channel. Through this they sailed, favored by a southwest wind, which opportunely continued until they reached the extremity of the passage near Point Conception. There the weather changed. A furious northwest gale, with a heavy sea, separated the ships and threw them back towards the islands The storm of two days subsided as the calendar marked "the feast of Holy Nicolas" (December 6) and the name of the saint, perhaps, in allusion to this event, was given to one of the Santa Barbara Islands. Soon afterwards the fleet rounded the cape which Cabrillo had doubled under like stress of weather sixty years earlier, and which he at the time gave the name of Cabo de Galera. Vizcaino named it "Punta de la limpia Conception," and it is still known as Point Conception.

Sailing along the coast towards Monterey the mariners came in sight of a range of high mountains which Cabrillo had seen at the same season of the year (early in winter) and named "Sierra de S. Martin." It was named by Vizcaino, "Sierra de Santa Lucia," probably because it came into view on the 13th of December, the day of the Holy Lucia. By that name the mountain range is yet known amongst Spaniards. The captains of returning Manilla vessels had been accustomed to recognize the coast of California by this landmark.

A small river, 2 leagues south of Point Pinos, also received the name which it still bears (Rio

*The configuration of San Diego harbor is well represented on his chart.

del Carmelo); and on the 16th of December the ships entered the Bahia de Pinos of Cabrillo, which, however, Vizcaino named in honor of the viceroy, la Bahia de Monte Rey. There he remained nearly three weeks, and from thence dispatched the Santo Tomas to Mexico with the invalids of his party, and a report, with a chart for the Viceroy, of all that had been developed geographically up to that date.

After providing wood and water Vizcaino sailed again to the northwest on the 3d of January, 1603. For several days the wind was favorable. They passed the entrance to San Francisco Bay, but on the 7th a heavy northwester separated the vessels, and they did not meet again until their arrival in Mexico. The Fregata was in advance, but supposing her to be delayed, Vizcaino entered the port of San Francisco in shelter of a cape, which he named Punta de los Reyes. So says Torquemada—but his Puerto de San Francisco is not the bay which now bears that name. Vizcaino wished to explore the place and search for vestiges of the crew and landing of the San Augustin which had been wrecked in 1595; but, anxious in regard to the missing Fregata, after a delay of two days he went to seek her at the northwest, the direction he supposed her to have taken.

To the little harbor in which he had anchored he gave the name which he had applied to the sheltering cape, calling it the Port of the Kings, probably because he discovered its entrance on "the day of the Kings," and perhaps also in allusion to the Fregata Los tres Reyes, which was lost in the same region. The name is not in Torquemada's extract, but it is on Vizcaino's chart. The former mentions only a "Punta de los Reyes" in this vicinity.

Beating and tacking against northwesterly winds, the San Diego advanced slowly. On the 12th of January a high projecting cape was reached in latitude 41½° north, thought by the pilots to be Cabo Mendocino, where they encountered a strong southeast storm, thick fogs, and a boisterous sea. Six only of the crew were capable of duty; the others and the officers and missionaries were sick (en las camas) in their beds.

Under these circumstances it was decided to turn back, but the storm lasted for some days and drove them still further north. At length, on the 21st of January, a northwest wind set in and cleared the atmosphere. They observed for latitude at 42° north (in their reckoning), where a white cape was in view, which they named "el Cabo Blanco de San Sebastian," because fair weather appeared on the eve of the day of the martyrs, San Fabian and San Sebastian. From thence they turned back to the southeast with a favorable wind. The cape is not indicated on Vizcaino's chart, nor is it marked to show either latitude or longitude. Later Spanish navigators have given the name Cabo San Sebastian to a point near the 42d parallel, now called Point George; but as before stated, if Torquemada puts Cape Mendocino one degree too far north, it is probable that other assigned positions are as much in error. Its true place therefore would be near Humboldt Bay or Trinidad Bay.

The home voyage was quickly made, and to allow observation the ship was steered as near to the coast as possible. But very little could be done, as the crew was sick with scurvy and some among them died. The intended survey of the other Santa Barbara Islands was of necessity renounced, as also the resolution to winter at Bahia de la Paz to wait for supplies. They sailed, therefore, directly for New Spain, and arrived in the harbor of Acapulco on the 21st of March, 1603, where they again met the crew of the Fregata.

The gale of the 6th of January, which had separated the two vessels, and from which the San Diego had sought shelter in the Puerto de San Francisco, had carried the Tres Reyes (commanded by Martin de Aguilar) some distance further north. Off Mendocino he encountered the same southeast storm which had forced Vizcaino into port, and was driven by it to latitude 43° north, according to an observation made on the 19th of January by the chief pilot, Antonio Flores. Here Aguilar gave the name of Cabo Blanco to a white cape, where (as Torquemada says) "the coast begins to turn to the northwest." Near it ran a deep and crooked river, which he attempted to enter, but its strong outward current baffled every effort.

After doubling Cape Mendocino, the Fregata, having advanced further north than was warranted by instructions, turned back southward; and the crew suffered greatly from scurvy. Aguilar and Flores died before the vessel which carried them reached San Diego. The ship

was, therefore, taken to Acapulco by the pilot, Estavan Lopez, and there he was joined by the Capitana.

The general opinion has been that the extreme limit reached by Aguilar was the present Cape Blanco or Orford, which is usually marked on Spanish maps "Cabo Blanco de Aguilar," but that supposition rests on the single observation for latitude made by the pilot, Flores. If the latitude stated in Torquemada for Cape Mendocino is one degree too high, we should look for this Cape Blanco somewhere about Point George; but there is near it no considerable stream, nor beyond it does the coast begin to turn to the northwest, but, on the contrary, trends somewhat eastward. Moreover, it is said by Vancouver that our Cape Blanco or Orford does not look white, being covered with dense forests down to the sea. To reconcile the discrepancies, or at least some of them, Captain Burney supposed that in January, when Aguilar was on the coast, every part exposed to the prevailing wind was probably whitened with snow. Near Point George the Klamath River empties, and beyond that entrance the coast inclines to the northwest. It is possible, therefore, that the position here referred to may have been the Cape Blanco of Aguilar, but the question cannot be decided. The river was not deemed of much consequence. Crooked and deep it is styled in the report, and doubtless it was magnified into undue importance, it may be, because that point was for a century and a half the northern limit of Spanish navigation. Every inlet or river mouth in that region was expected to be or to lead into the Strait of Anian, or into the western end of some passage around America. Aguilar's cape and river are noticed in all geographical books, and are marked on nearly all maps of the seventeenth and eighteenth centuries.

This expedition of Vizcaino, like that of Cabrillo, was more successful than other Spanish voyages to the northwest. Both saw the same stretch of coast, and reached about the same latitude. Vizcaino observed everything closely, and his work deserves to be called a detailed reconnaissance. His desire was to push exploration northward; find the Strait of Anian; sail around America, and return by that route to Spain. But these schemes were never accomplished. Vizcaino went to Spain, and after much exertion obtained from Philip III an order for the furtherance of his projects, but before needful arrangements could be completed he died, and with him expired the spirit of enterprise. It was, says Navarrete, "an epoch in which the Spanish nation retrograded." Spain was not afterwards governed by such monarchs as Ferdinand, Charles, and Philip II.

NEW MEXICO.

During the seventeenth century the court of Spain was beset by applicants, native and foreign, offering vague projects for the development of the Straits of Anian; and many unsuccessful expeditions were planned for settlements on the peninsula of California. Throughout the century nothing was done to advance knowledge respecting the geography of the northwest. That region seemed to be forgotten. There was, however, one expedition planned near the close of the previous century, and accomplished, which to a certain degree connected with the geographical history of the western coast. This was the discovery, conquest, and settlement of New Mexico. The enteprise, like many others, was suggested by a Franciscan monk, Friar Augustin Ruiz, who lived in the valley of San Bartolomeo, near the silver mines of Santa Barbara, at the outskirts of the Spanish settlements. As early as 1581 he had journeyed among the Indians at the north, and brought back intelligence of a beautiful and populous valley through which flowed a river several hundred leagues in length.

Antonio de Espejo, a wealthy and energetic man, put himself at the head of a company of soldiers, and with some Franciscan monks marched, in 1582, to search for the valley and river described by Ruiz. As he afterwards reported, Espejo reached "nearly to the source of the river" and found every where villages and towns, with the inhabitants of which he held friendly intercourse. He also made a journey to the eastward through the buffalo country, and another westward as far as Cibola and the river Gila, where Coronado had been previously.

In 1583, Espejo returned to Mexico and reported his discoveries. Attempts were made at intervals for the conquest of the interior, and at length Monterey, the Viceroy who had directed the voyages of Vizcaino, struck a decisive blow. He dispatched Juan de Oñate, an officer of high

repute, with an army of about one hundred Spaniards and five hundred Indians, to the north, took possession of the country, and gave to it the name of New Mexico. Thus Oñate became the founder and first governor of the new province, and in it was established, in 1611, the flourishing capital of Santa Fé.

In these contemporaneous expeditions of Vizcaino and Oñate may be traced a correspondence with the sea and land enterprises of Alarcon and Coronado, sent out by Mendoza.

The upper valley of the Rio del Norte is a fertile oasis in the midst of deserts. Santa Fé soon became a station of great importance as the depot for all Spanish expeditions to the eastern, northern, and western regions. From thence discovery was pushed to Lake Utah, called by the Spaniards "Timpanagos," and westward far into the territory watered by the river Gila. After the settlement of the coast of California a road was laid out, terminating at Santa Fé.

The first explorers of the valley of the Rio del Norte reached that river near the great bend called El Paso, where the channel takes an easterly course towards the Gulf of Mexico. The Spaniards had explored only the upper valley. They knew indeed of the Rio Bravo, but believed it to be a separate river, having followed it only to El Paso where the stream is hidden amongst rocks and mountains. Ignorant of the course, the termination was supposed to be in one of the rivers of Cinaloa, or some water-course emptying into the Gulf of California. The discovery, therefore, of the Rio del Norte was considered by many as pertaining to the history of the northwestern side of America, and as merely an addition to their knowledge of the Pacific basin. This hypothesis, or rather geographical error, was long maintained, but was corrected on European maps by Coronelli about the year 1680.

Of the fabulous accounts in regard to discovery, circulated between 1609 and 1625, only two are deserving of mention, namely, those of Ferrer Maldonado and the so-called Juan de Fuca.

The false reports were repeatedly disproved, but they influenced the history of geography. Maps were constructed and the erroneous details were admitted in historical works. Names attached to the assumed discoveries were given to previously known localities as well as to imaginary straits, rivers, and countries. Expeditions were organized and instructions were issued for exploring the regions that had been fictitiously described. In 1790, the officers of the Spanish expedition of the Descubierta and Atrevida were directed to explore the coasts, straits, and harbors supposed to have been discovered by Maldonado.* The influence of these stories dates from the time of their promulgation, and not from the period at which the incidents were supposed to have occurred. Maldonado pretended that he sailed in the year 1588, but the "results" of his voyage were not given to the world until the year 1609. De Fuca, though his expedition was said to have been made in 1592, brought no account of it before the public previous to the year 1625. In a chronological record of discoveries these impositions must be referred to the time of their publication.

Lorenzo Ferrer Maldonado was well known in Spain as a schemer and adventurer, and his story touches but lightly the geography and history of California. He pretended to have sailed from Lisbon to Labrador in 1588; and from Labrador to the Pacific through a narrow strait by which a passage from Spain to China could be accomplished in three months. In 1609 he presented to the Spanish Government a report on discoveries and added a proposal to return to the spot and employ himself in erecting fortifications against the encroachment of foreigners. But, after careful examination, his statements were decided to be false, and his proposition was of course rejected. He was treated as an ignorant impostor and charlatan. Some subsequent historians, nevertheless, ready to believe any wonderful tale, mention these pretended travels and discoveries; and thus the subject was kept alive through the seventeenth and eighteenth centuries. Copies of Maldonado's original papers deposited in the Spanish archives found their way, we know not how, into foreign countries, and near the end of the eighteenth century (1790) the French geographer, Buache, "who clung fondly to questionable discoveries," drew attention to them by declaring his confidence in the veracity of Maldonado's statements. The last, perhaps, to give credence to the narrative of adventures was the Italian savant Amoretti who in 1812 edited an old manuscript found in the Ambrosian Library, which manuscript he supposed to be a copy of the original report.

* See "Oregon Question," p. 82, and Navarrete, p. li.

We need not enter minutely on the subject, as it bears only a remote relation to our object. The reader is referred to Navarrete, pp. xlix–lii; Twiss, "The Oregon Question," London, 1846 pp. 79–82; London Quarterly Review, 1816, vol. 16, pp. 129–172. The author of the article in the Quarterly thinks it possible that Maldonado might have seen Cook's River, and mistaken it for a strait between America and Asia. See also Burney's History of Voyages to the South Sea, vol. V; and Barrow's Chronological History of Voyages to the Arctic Bay.

The story of Juan de Fuca bears more directly on one subject. It was first printed by Purchas in his third volume, and was published in 1625, although it seems to have been in manuscript some time earlier, and may have been known to a few persons. The Englishman Lok relates, in the report published by Purchas, that he met in Venice an old Greek navigator named Juan de Fuca or Apostolos Valerianos, who told him that he had been a captain in the Spanish service, and as such had been sent in 1592 to the northwest in command of a small vessel by the Viceroy of Mexico, probably Don Luis de Velasco, who filled that post from 1590 to 1595. He stated that he had sailed along the coast of California beyond the forty-seventh parallel of north latitude; and there found the coast trending east and northeast, forming with the opposite shore a broad inlet. At the entrance he said there was a remarkable rock, having the appearance of an island, and northwest of it a pyramidal rock.

Beyond this strait spread a wide inland sea, which stretched into openings towards the south, the north, and the east. At various places on the shores he had found fertile country and natives clothed in the skins of animals. He further asserted that he sailed a long course through open water, and after passing many islands came out into the North Sea or Atlantic Ocean, from whence he returned to Mexico and reported to the viceroy. He had also reported in person to the King of Spain, but though well received in both instances his services were not properly rewarded, and he finally returned to the island of Cephalonia, where he belonged.

This account soon after appeared in a work published by Lucas Fox, and was repeated by many writers. Believers in the truth of the narrative were numerous in the seventeenth and eighteenth centuries. De Fuca's discoveries, like those of Maldonado, were represented on maps, and De Fuca's Strait is laid down north of California in contemporary works, at about 47 or 48 degrees of north latitude.

Towards the end of the eighteenth century such a strait as De Fuca has described was found beyond the forty-eighth parallel, trending eastward, opening into wide water, having many islands and inlets to the south, north, and east; surrounded, too, by a fertile country, and peopled by fur-clad inhabitants. Some travelers thought they recognized the pillar-like rock on the southern side of the entrance, as he had represented.

Many were induced to believe in the truthfulness of De Fuca's report, and the channel was named De Fuca's Strait. Some thought that the first part of his story, so far as it related to the channel and a broad gulf beyond, might be true, but doubts were entertained in regard to his coming out upon the Atlantic. It seems likely that he passed around Vancouver's Island, after being in the Gulf of Georgia, and so passed into the Pacific. But Navarrete asserts that no navigator of the name Juan de Fuca or Apostolos Valerianos was ever at any time known in Spain or mentioned by contemporary Spanish writers; nor is there extant any record of the visit of such a person to the King of Spain or to the viceroy of Mexico. In none of the papers relating to the expeditions of Vizcaino, written only a few years after 1592 (the time of De Fuca's supposed voyage), can be found any allusion to him; nor is any document bearing on his history in the archives of Sevilla or New Spain. It seems probable that Juan de Fuca never made a voyage in the service of the viceroy of Spain, nor discovered a strait in the latitude indicated, and it may be considered as a mere accident that in the beginning of the seventeenth century a strait in that region was described in a manner coinciding so nearly with the reality as ascertained at a much later date.

The history of Spanish expeditions to the peninsula of California is somewhat tedious. They were not ably conducted; they entailed large expense; scarcely furthered the progress of discovery; and in no instance enlarged the boundaries of the Spanish settlements In fact, they touched only the southern part of the eastern coast of the peninsula. The western coast of the peninsula was not surveyed, nor was the upper end of the Sea of Cortes visited for many years. Its configuration, well

known in the time of Cortes and Mendoza, was so utterly forgotten that the gulf was supposed to extend to the forty-eighth parallel, and that it connected there by a channel, both with the Pacific Ocean and with the Atlantic. California was considered, therefore, not as part of the continent, but as a large island reaching from De Fuca Strait to Cape San Lucas. This erroneous notion seems to have originated with some Dutch freebooters called Pichilingues, who in the beginning of the seventeenth century formed a piratical settlement in the Bay of Pichilingue, on the southern coast of California. They caused it to be reported in Holland that a vessel had once sailed through the Sea of Cortes (Gulf of California) to the north, and from thence had come out upon the Pacific, thus circumnavigating the whole area of California. The story was believed, and a map constructed to accord with it was sent to England. Purchas, who was one of the earliest adherents of this geographical theory, published an account of it in 1625 in the third volume of his Pilgrims, and inserted also the first printed map of North America, on which California is represented as an island, and the Sea of Cortes as a broad channel of enormous length. The views of Purchas were adopted by nearly all the geographers of the time. Spaniards, even forgetting the maps of Castillo and their other pilots (then lying in the Spanish archives), shared at last fully in the belief, and about the year 1670 changed the name California to another in honor of their sovereign, Charles II. They named the country "las Islas Carolinas," intimating that it formed a cluster of large islands.

The unsuccessful attempts made at this time by Spaniards, in regard to discovery and development, appear as types of the condition into which the great Spanish monarchy had fallen. In this prostration Mexico participated. Commonplace explorers with great pretensions were sent out, and were styled "Admirals"; but they were feeble in comparison with such captains as Ulloa, Cabrillo, and Vizcaino.

After the death of Vizcaino, the first who was commissioned to conduct an expedition to California appears to have been Juan Iturbi. With two ships he passed along the greater part of the eastern coast of the peninsula, and as far north as 30°, but was driven back by northwesterly winds, and in distress reached the shores of Cinaloa, where he was received by the Jesuit missionaries, who saved his life. Father Andres Perez de Ribas, a Jesuit, wrote the history of this expedition.

One of the vessels of Iturbi had been captured by the Pichilengues, and it was feared that those pirates might attack also the returning Manilla galleon. Iturbi, therefore, on arrival, was sent out again to protect the galleon, and the further exploration of California was abandoned. There was no other effort in regard to that object made until 1632, when Francisco de Ortega attempted it. He surveyed only a small part of the coast between Cape San Lucas and the Bahia de la Paz, and from the last-mentioned place made his way back to Mexico. In 1633 and 1634, he made two other voyages to the same region, with the intention of founding a settlement, but the attempt was unsuccessful.

Iturbi seems to have derived some profit from the pearl fisheries, which were then still productive. Spanish settlers on the coast of Mexico and Cinaloa were thereby induced to fit out vessels and cross the Gulf of California to seek for pearls on the opposite shore.

In official expeditions, or such as were assisted and favored by Government, Ortega was followed by his pilot, Estavan Carboneli, who affirmed that his chief had failed from want of knowledge and courage. Carboneli promised to find, in a higher latitude, a more fertile country, better adapted for settlement, and he set sail for that object in the year 1536. He "advanced as far north as he could," to what latitude is not stated, but only sterile rocks and poor Indians were to be seen. He collected some pearls, as others had who preceded him, and returned to New Spain, where Ortega saw him derided, in turn, as an ignorant poltroon.

Venegas says that one reason why these repeated expeditions to California did not succeed was that no care was taken of former reports, surveys, maps or plans. "They were not carefully preserved and made known by print."

The usefulness of the enterprise being evident, it was renewed in the year 1642 by the viceroy Don Diego Lopez Pacheco, who sent on this occasion the governor of Cinaloa, Don Luis Cestin de Canas, with soldiers and missionaries, with the often repeated instructions "to survey the coasts, bays, islands, rivers, inlets, and creeks of California." The result was much the same as

in former instances. Cestin visited Bahia de la Paz, and from thence sailed along the coast, but only "forty leagues to the northwest." Father Jacinto Cortes, a Jesuit missionary who accompanied him, wrote a report of the expedition, which report was sent to the Viceroy, with some pearls which had been collected on the coast.

Governor Cestin was followed in adventure by the Admiral Don Pedro Porter de Casanate Venegas so writes the name, but in Navarrete it is written "Porter y Casanata."

Casanate embarked for California in 1643. Three years earlier that officer had been commissioned to survey the coasts of the Pacific in the immediate vicinity of the peninsula (Lower California) and to make soundings. Navarrete says that the results, after presentation to the council of the Indies, were deposited with other documents in the "Archives of India."

Duly empowered in 1640 to make the intended exploration, Casanate had also, by authority, a monopoly in regard to navigation in the Gulf. The reason of his detention in Spain is not explained. In 1644, when his expedition was ready, he was ordered to sail without delay toward Cape San Lucas, to convey the Manilla galleon, and protect it against some English and Dutch pirates who had been seen in the waters of New Spain. At length the survey was commenced on the eastern coast of the peninsula, but was again deferred in consequence of an urgent call to guard the Manilla vessels against the ever-threatening pirates.

Thus interrupted, the Admiral did not return to California, but reporting the difficulty of the undertaking to the Viceroy of Mexico, he was soon afterwards sent to South America and made Governor of Chili. His abortive undertakings in regard to geographical development were so discouraging that an interval of twenty years elapsed in which nothing was done. But, towards the end of the reign of Philip IV, an order was issued for further exploration. The command of an expedition was intrusted to Admiral Don Bernardo Bernal de Piñadero. The outfit was small, as the condition of the Spanish treasury was low. With two small vessels he sailed, in 1664, for California. Instead, however, of surveying the coast, the avaricious soldiers of the party would attend to nothing except pearl fishing. They forced the natives to do all the heavy work for them, and when a quantity of pearls had been secured they quarreled among themselves in the division. Piñadero, for himself, secured a small share, but was constantly engaged in efforts to keep his men from quarreling.

A second voyage by the same admiral in 1667 was not more successful, and no result marked the next expedition, which was led by Francisco Lucenilla in 1668.

Philip IV, the monarch who had directed the last-mentioned enterprises, died in 1665. In the early part of the reign of his successor, Charles II, nothing was done. But the Council of the Indies, aware of the advantages that might result from the conquest of California, determined to renew efforts towards that end. In the year 1677, orders for the purpose were issued to the Viceroy of Mexico, and a contract was made with the Admiral Don Isidoro de Atondo as commander, who was confident of success notwithstanding the failure of all his predecessors.

On the 18th of May, 1683, Atondo sailed with two ships carrying sailors and soldiers, and a third vessel laden with implements, munitions, and provisions. He arrived at Bahia de la Paz and fortified against hostile Indians, but the store-ship, beaten off by storms, was so long delayed that the soldiers suffered for want of food. One of the vessels was therefore sent to New Spain and obtained a cargo, but was unable to reach port. Three attempts were made, but the vessel was driven back although in sight of the coast. Under these circumstances Atondo found it impossible to maintain order, and was obliged to abandon his position at La Paz. By the sale of everything he could dispense with he was enabled to procure provisions, and he embarked for a more northern bay in latitude 46° 30′, which he called San Bruno. This doubtless was the bay afterwards called by the Jesuits "Bahia de la Conception."

On his arrival Atondo commenced a settlement, built a church, and passed a year in exploring the neighboring regions. He made distant excursions, and tried by traversing the peninsula to reach the Pacific side. On these journeys, and generally in his travels, he was accompanied by missionary Jesuits, who thus became thoroughly acquainted with the country and learned the languages of the natives. At the head of these missionaries was the intelligent Father Kino, or Kuhn, a German, who had served as cosmographer (cosmografo mayor) in the expedition, and who subsequently wrote a very interesting account of it.

Atondo seems to have been energetic, but he spent nearly three years in ineffectual attempts to make a settlement in California. Finding it impossible to procure means for maintaining a colony, in the autumn of 1685 he re-embarked the soldiers and missionaries, and taking a few of the baptized Indians, returned to Mexico. There he found other employment, and in addition was ordered to start to oppose pirates and convoy home the Manilla galleons. Nothing was gained by the expeditions of Atondo. They were costly, and consequently there was little disposition either in Mexico or Spain to incur further outlay. The government of Mexico, says Father Baegert "renounced not only all activity in this direction, but actually refused assistance and protection for private undertakings to California."

1697–1717.

California, thus abandoned by the Spanish Government, still had the attention of the Jesuits, who were then powerful and active in both divisions of the western hemisphere. They had established missions along the eastern side of the Gulf of California, and through Cinaloa, Sonora, and Pimeria, and furnished missionaries, journalists, cosmographers, and historians to nearly all the Government expeditions, down to that of Admiral Atondo, who was, as already stated, accompanied by Father Kino. These pious men thought that by preaching to the Indians, and conversing with and civilizing them, might be accomplished, what no avaricious merchant or pearl fisher, no sailor or soldier, however courageous, had been able to effect, the settlement and exploration of California. They proposed therefore a system of procedure in which missionaries should not be subordinate either to a military or naval chieftain. Missionaries were to take the lead with an army at their command.

The most complete history of the Jesuits in California is "Noticia de la California y de sucon. quista temporal y espiritual hasta el tiempo presente, sacada de la historia manuscripta formado in Mexico año de 1739, por el padre Miguel Venegas, de la Compañia de Jesus; y de otras Noticias y Relaciones antiqnas y modernas Añaclida de algunos mapas particulares, Madrid, 1757." The work is in three volumes, and is generally ascribed to Venegas; but the history of California is carried by him only down to the year 1739. Andreas Marco Burriel compiled from the manuscripts of Venegas and from other sources and issued an edition in 1752. The work is valuable, but there are misprints in regard to the chronology. The third volume contains interesting quotations from other authors and treatises on geographical questions relating to California.

On the subsequent history of the Jesuits in California, from 1752 to 1767, when they were compelled to leave that country, many books have been published. One of the most valuable of these was written by Baegert, and was printed in 1773. Baegert was a German Jesuit who passed much time in California. His clear narrative and description of the country include references to the missions and journeys, and mention of the close of that religious order on the coast. This work also was translated into English and some other languages.

Juan Maria Salvatierra, an Italian nobleman of Milan, and a Jesuit, was at this time in Mexico. He was known as a man "of zealous faith, of large mind, and of great patience, and withal of a strong bodily constitution." While visiting the mission of Sonora he met the German Jesuit Franz Kuhn (called by the Spaniards Francisco Kino), who told him of the neglected state of the country and of the misery of its inhabitants. This relation kindled in the mind of Salvatierra a desire for Christianizing the Indians. He finally received permission to go to California, but nothing was to be expended from the royal treasury on his account.

Salvatierra was poor, but a wealthy gentleman of Acapulco, Gil de la Sierpe, placed at his disposal two vessels and a sum of money. He received contributions also from Europe. Five soldiers, several seamen, and some associates accompanied him, and, having procured a cannon, with provisions for the expedition, he sailed, in October, 1697, from Cinaloa to the coast of California, and settled in latitude about 26° north, where he founded a mission which he called San Loretto. He preached to the Indians in their own language, baptized them, and resolved to pass his life in religious work. More than twenty times he crossed the Mar Vermejo, and was enabled by the assistance of his friends in Mexico to procure men, missionaries, and provisions, and to found several other missions on the coast of California. Between the years 1697 and 1716 he

expended in this work 300,000 "pesos duros," collected by himself and his pious companions from devoted individuals and corporations in sympathy with the cause.

This was the first of several Jesuit missions in Lower California. They attracted attention in Europe, and were believed to be constituents of a powerful domination aiming at riches and empire. Such was the accusation, and it resulted in the dissolution of the order.

What the Dane Egede did for Greenland, Salvatierra effected for California. He labored also for the exploration of the country, made excursions to the interior, and decided the long-standing doubt concerning the peninsula, which by many was supposed to be an island. At his request, Father Kino traversed the country from Sonora to the Rio Colorado. The usual residence of Kino was the mission of Neustra Sonora de Dolores, on the northern frontier of Sonora. In one of his journeys (in the year 1700) he followed the course of the river Gila down to its junction with the Colorado, but for want of provisions could proceed no further. Before returning he ascended a mountain, and, looking westward and southward, saw continuous land. Venegas says that with "a spy-glass" he traced the course of the Colorado to the gulf and recognized the mountains. Convinced of the continuity of land between Sonora and California, and assured also by the Indians of different tribes assembled around him (about five hundred in all), Kino yielded to the necessity forced on him by the sickness of his companions, as well as want of provisions, and returned home.

Though highly pleased, Salvatierra was not entirely satisfied with a conclusion based on a distant view. He required practical proof. Nothing less than actually walking around the gulf on dry land would thoroughly settle the question. The Fathers therefore proposed to set out from Kino's mission Dolores, in Sonora, walk around the gulf, and down on its western side to the mission of Salvatierra (San Loretto), in California. Salvatierra joined his companion at Sonora, and both set out on this expedition from Dolores on the 1st of March, 1701. Taking a route different from the one traveled by Kino previously, they did not go as far north as the Gila, but turned westward to follow the shore of the gulf, and reached a sandy, waterless desert, in which the party suffered with heat. They were obliged, therefore, to content themselves with a view of the shores from an elevation of the Sierra de Santa Clara, a mountain range, where the party assembled, and from thence saw the coast of California, the narrow northern end of the lake, and the mouth of the Colorado, after which they returned to Dolores.

At the end of the same year, 1701, Father Kino again went north and followed the Gila and Colorado to avoid the sandy desert. He passed down the Colorado, landed on the western shore, and in the country adjacent found only wide plains and saw hills in the distance, but no appearance of any prolongation of the Gulf. The Indians told him of the ocean, and showed him shells from the "contra costa," which, they said, could be reached in ten days' walking. Kino wished to make a journey to Monterey and also to Cape Mendocino, but being unable to cross the Colorado with horses and mules he wrote to Salvatierra from the western side of the river, and sent the letter by an Indian, trusting that it might be forwarded to San Loretto.

In 1702 Kino made the last of his excursions, and was then accompanied by Father Martin Gonzalez. Again he reached the junction of the Gila and Colorado, and from thence passed along the eastern shore of the last-named river, and reached its mouth, which until then Kino had only seen from afar. There many friendly Indians from the western side gathered around him, described their country, its rivers and mountains, and stating the distance to the ocean, invited him to visit their settlement. But Kino was again prevented from going westward. His companion, Gonzalez, fell sick and died, and was buried on the road. Occupied with missionary duties elsewhere, Kino was unable afterwards to visit the northern end of the gulf. He died in 1710 and Father Salvatierra in 1717, leaving unsettled the question in regard to the continental character of California.

JUAN UGARTE, 1721.

The Gulf of California had been partially examined. Its shores had been looked at from the mast of some distant vessel, but the indentations were scarcely known.

The first traveler who gave particular attention to such details was the Father, Juan Ugarte, who, in 1721, built two small vessels and sailed on the 15th of May from the Bay of San Dionisio

de Loretto. With the crews were several who had passed through the Strait of Magellan, and also an able and intelligent pilot, Guillermo Estrafort.

Sailing north along the eastern coast of the gulf this party closely examined the shores, corrected the errors of early maps, and after encountering dangers and difficulties reached the mouth of the Colorado early in July. In the middle of that month they turned back, and on the home voyage surveyed parts of the eastern and western shores of the Gulf. In September, 1721, they arrived at the port of San Loretto, and there announced that between the Peninsula of California and the Province of Pimeria there was no water excepting that of the Rio Colorado.

Father Ugarte wrote an account of this expedition and appended to it the map of his pilot, Estrafort, which map, says Venegas, he considered the principal result of the undertaking, but neither the narration nor the map seem to have been published.

1732.

The Jesuits had for a long period manifested interest in the exploration of the interior of the peninsula and of what was then called "contra costa," or the seaward side of the peninsula. They, in fact, inherited the purpose of forming some settlement for the benefit of the returning Manilla galleons. Several "entradas" had been made, the first by Father Ugarte, after many difficulties, in the year 1706, when a tract of about 20 leagues was surveyed near the twenty-fifth degree of north latitude. A company, conducted by the same Father, in 1712 founded not far from the ocean (at about 26° north latitude) the mission of Purissima Concepcion de Maria, and surveyed part of the coast. In 1719 Father Clemente Guiken led an expedition to the vicinity of 24½ north latitude, and examined Bahia de Magdalena, which had been named by Vizcaino, and noted by him as one of the best protected ports in that region. In that neighborhood the mission of San Luis Gonzaga was established by the Jesuits. But the most interesting of the expeditions patronized by that order was accomplished by Sigismundo Taraval, in 1732.

Born of noble parents at Todi, in Lombardy, Taraval was well instructed. In the year 1730, and when in the prime of manhood, he arrived in California. The most northwesterly mission then maintained was at San Ignacio, near 28 degrees north latitude, the care of which was confided to Taraval, with directions to explore the region beyond and open the way for similar establishments. Putting himself at the head of a company of baptized and friendly Indians, he traveled six days and reached a bay, which he called Bahia de San Xavier, the latitude of which is not stated in the narrative. There he saw several small islands, distant 6 or 7 leagues from the coast; and after constructing a *balsa*, sailed over to one of them but found only birds. So he named the group "Islas de Aves," *i. e.*, Bird Islands. Another island, some leagues from these, in latitude about 31 degrees north, he named "Isla de Neblinas," or Foggy Island. In the interior of this last was a considerable mountain which Taraval ascended, and at a distance of 8 or 10 leagues saw a cluster of islands, which he named "Islas de los Dolores." Against the horizon other islands were seen at the north, which he supposed to be the Santa Barbara group, one of which had been called "Isla de Santa Catalina" by the navigator Vizcaino. There is little doubt that the "Dolores" mentioned by Taraval were the Coronados Islands.

On the map of North America, in the third volume of the History of California by Venegas, these islands are put down in latitude 32 degrees north, and are marked "Islas de los Dolores, reconocidas por el Padre Sigismundo Taraval en 1732."

The bay named by Taraval "Bahia de San Xavier" is not indicated on this or on any other map. Probably it is the small bay now known as San Diego Harbor. Venegas says that Vizcaino passed, perhaps in the night, from the harbor of San Diego to the Bay of San Xavier, and then discovered near this bay the island of Catalina.

After Taraval no Jesuit missionary went so far north of Mexico. "We wished very much," says Venegas, "to found missions on the islands of the Santa Barbara Channel, seen by our father, but the distance was too great, and we had still too much to do in our immediate vicinity."

1746.

An expedition similar to that of Ugarte in 1721 was undertaken by Father Fernando Consak, a native of Bohemia, in 1746. With four canoes, he started from the bay of San Carlos (latitude

28 degrees north) on the 9th of June. His undertaking closely resembles that of Ugarte, both in regard to route and as respects the conclusions. Consak explored the coasts, bays, inlets, and islands along the eastern shore of Lower California, and on the 11th of July arrived at the mouth of the Colorado. He tried to ascend the river with his canoes, but the current was too strong for his oarsmen to admit of any considerable advance. He surveyed, however, on the return some parts of the gulf, and constructed a map, of which Venegas gives a copy in the third volume of his History of California.

1766.

As no one had actually walked round the northern end of the Gulf of California, some doubt remained. To settle the matter finally, Father Winceslaus Link was sent, in 1766, to go by land through the peninsula toward the Rio Colorado. He was then in charge of the mission of *San Borgia*, then the most northerly establishment of the Jesuits. The journey was commenced with sixteen Spanish soldiers and one hundred Indians. After a weary march they reached a point 20 or 30 leagues from the Colorado, and there his Indians were all sick; his horses and mules died, and the soldiers were so much dispirited that Link was obliged to retrace his steps. As far as could be seen, however, he discovered only sandy plains about the north end of the gulf, and like those who preceded him, it was reported to be landlocked. From his time Lower California has been universally known as a peninsula. A few years after this the Jesuits were forced to leave the country which they had explored, cultivated, and peacefully governed. For some years an opinion prevailed in Europe that the Jesuits had in California and in Paraguay, powerful and populous empires, and that enormous wealth had been derived from their gold mines and pearl fisheries. When therefore the dissolution of the order throughout the world was decreed, the viceroy of Mexico (in 1767) sent an armed force, under Don Gaspar de Portola, to California, with directions to seize the country in the King's name and assume jurisdiction as Royal Governor. The Jesuits were arrested at their several missions and sent to Spain. Some perished, and others, after much suffering, reached Europe. Portola was not resisted, but he found instead of the expected El Dorado, a very poor, rocky country, with only wild tribes of Indians, who had made under the guidance of the Jesuits, their first advances toward civilization.

Franciscan friars were substituted for the displaced missionaries, and the work of colonization inclined toward the far northwest. In the course of twenty-five years that region was rapidly developed.

RUSSIAN EXPEDITIONS.

The Jesuits, by their settlements and exploration of the peninsula and Gulf of California, laid a foundation for farther progress towards the northwest. Two European nations, the Russians and the French, advanced from opposite directions to the same region. Their enterprises influenced the ideas of geographers, and moved the Spanish Government to make a final exploration of that part of the country.

A sketch will suffice to mark the discoveries made by Russians in their expeditions from Siberia. Cossacks had passed the Ural Mountains and commenced an easterly movement at the end of the sixteenth century. They traversed Siberia and arrived on the shores of the Northern Pacific by the middle of the seventeenth century. One of these named Deschnew, as early as 1646, sailed through Bering Strait, but left no detailed account of his adventures. Others followed, and by reaching the peninsula of Kamtchatka gave the Cossacks some notion of lands east of Siberia. There had been amongst them the rumor of an "eastern country or island," with large rivers and forests in which were fur-bearing animals. The enterprising monarch, Peter the Great, formed a plan for the exploration of the region, but his death not long afterwards devolved the execution of the scheme upon his successor.

In 1728 Capt. Victus Bering, chosen by the Emperor Peter for the undertaking, sailed from Kamtchatka and took a northeasterly course. He saw only the western part of the gulf which bears his name, crossed the strait dividing Asia from America (traversed by Deschnew),

and reached, at the sixty-sixth parallel, a promontory which he believed to be the most northern headland of Asia. From that point he returned home.

In the time of the Empress Elizabeth (1741), a more important expedition moved, under command of the same Bering. With two ships, one in charge of Captain Tschirikow, a Russian, he sailed from Kamtchatka in a southern and eastern direction. The vessels were soon separated by a storm, but both reached the coast of America, though at different points. Bering made land under 60 degrees north latitude in the neighborhood of a large mountain, called since his time Mount Saint Elias, and Tschirikow at 56 degrees north latitude touched on one of the islands now known as the Prince of Wales Archipelago; but neither of the commanders could go farther. Their crews were sick and their means of subsistence exhausted. On the home voyage they saw some of the Aleutian Islands. On a small island west of them Bering was wrecked and died, but his crew and Captain Tschirikow's returned safely to Kamtchatka before the end of 1741, bearing the news of their discoveries to Europe.

The operations last mentioned resulted in the introduction of a new fur-bearing animal, the sea otter, which soon became one of the chief inducements for future expeditions and explorations in the northwest. On the island where Bering died his crew killed many of these animals, and in China sold the skins at large prices.

The Russian Government did not at once follow up the geographical discoveries of Bering, but enterprising individuals fitted out private expeditions to hunt the otter. None of these reached the coasts visited by Bering and Tschirikow, but they explored the Aleutian Islands and brought home some sketches and maps.

In 1764 the Russians occupied the peninsula of Aliaska, on the continent of America, mistaking it for an island, and formed different trading establishments and hunting stations. At length these attracted the attention of the Russian Government, and induced an official investigation in regard to their extent and connection with other countries.

By order of the Empress Catharine II, expeditions were dispatched about the time of the expulsion of the Jesuits from California, and the substitution of more active explorers (the Franciscan missionaries) to fill places vacated by that religious order. The first was sent in 1766-'67, under command of Lieutenant Synd, and the second in 1768, in charge of Captain Krinitzyn and Lieutenant Lewashoff. But these navigators failed in attempting to reach the latitudes attained by Bering and Tschirikow. They effected nothing except a little improvement in the knowledge of the position and condition of the Aleutian fur islands. The attention of the Spanish Government, anxious to preserve and defend its old pretensions to the possession of the Pacific, was excited by these movements. They were regarded as invasions of Spanish California.

FRENCH EXPEDITIONS.

The expeditions of the French, sent out westward from Canada, and their discoveries, like those of the Russians, could not but influence the views held in regard to the nature and configuration of the northwestern coast. On the Saint Lawrence the French were told of a great expanse of water at the westward, and they supposed it to be the Pacific Ocean, as, according to opinions then prevalent, the continent was not of very great breadth. The first English settlers in Virginia believed that beyond the Alleghany Mountains there was a large sea, supposed by some to be the Pacific, by others only a bay or branch of the Gulf of Cortes (Californian Gulf), and that supposed sea is marked on some of the early maps of Virginia.

The French had found that the so-called "Great Sea" was merely a series of lakes. In 1673, by passing the Mississippi they disproved also the supposition in regard to the proximity of the Pacific. Its coast was, however, in imagination, removed only so far west as was made needful in representation by positive evidence. It remained a favorite idea with the Canadian, French, and Virginian English that the continental breadth was not great, and at each step westward they expected to find water courses running in that direction.

In the year 1683, soon after the discovery of the Mississippi, a French traveler, the Baron Lahonlan, while exploring the river "Moingona" (perhaps the Minnesota), met some Indians who told him of a river running westward. One of them painted upon a buffalo skin a map of the

river with its mouth opening into a large expanse of water; and on the shores of that expanse were towns and trading vessels. This story is like the vision of the Spaniard, Coronado, who also saw salt water at the west, with great gilded trading ships. Lahonlan brought home a map, and we see in consequence on French publications of that day a great western river not far from the Mississippi, and in addition the shore of a broad stretch of salt water, but whether intended for a large inland lake (Utah?) or part of the Californian gulf, or the Pacific itshlf, cannot be decided.

In 1721 Charlevoix, a French Jesuit, went down the Mississippi, and was told by Indians near the mouth of the Missouri that they had been westward and found its source in very high mountains, on the other side of which was a stream flowing towards the west. A similar but more circumstantial account of this western river was given by an Indian to Du Pratz, another French traveler, in 1735. He called it Tacoutche Tessee, and said he had traveled from its source to its mouth, or as far down as the great water towards the setting sun. Amongst Indians on the upper waters of the Missouri some French voyagers saw sea-shells, which had probably come from hand to hand over the Rocky Mountains to the valley of the Mississippi, and these were considered as sure indications that an ocean existed in the west.

In the northwest the French discovered and traced the river of the Assinaboines and the Saskatchawan, obtained some knowledge of the Rocky Mountains, and also heard again of the "Great River of the West."

Amongst the travelers in that region was the Chevalier de la Verenderye, a man of enterprising spirit, who, with his sons, manifested steady interest in geographical development, but it is not probable that he actually reached the mountains. He went far in that direction, and pictured them on his map, as also the river of the west, which is represented as an outflow of Lake Winnipeg. The French map-makers who followed his indications, as, for example, N. Bellin, in 1743, not only sketched the river, but added some parts of the coast of the Pacific, which they adopted as the western boundary of La Nouvelle France, or "Canada." Opinions respecting the mouth of the river were as various as those held in regard to the source. Some thought that it led to the harbor of San Francisco, where two western rivers do in fact join their waters. Others supposed it to flow in the opening seen by Martin d'Aguilar, and some had in view an outlet towards the Strait of Juan de Fuca.

The English traveler Carver, who, like Verenderye, set out intending to reach the Pacific, says: "The river Oregon, or River of the West, falls into the Pacific Ocean at the Strait of Anian." Müller, the able German historian of Russian discoveries, says: "According to my opinion, the much spoken of Great River of the West falls into the ocean opposite either to Kamtchatka or the country of the Tschuktschi."

Spaniards showed on maps of the country northwest of Mexico some large rivers, but the directions are marked as uncertain. Their names are Rio Dolores, Rio Buenaventura, Rio San Felipé, Rio Los Monges, and others. Some believed these to be independent streams, but others supposed they were branches of one large river, probably the Oregon, mentioned by Carver, or, as named by the French, "Rivière de l'Ouest."

The French lost control in Canada before their explorations could be extended from the Saint Lawrence and Mississippi towards the Pacific. Others completed the work, as will be mentioned hereafter. Neither the expeditions of the Jesuits nor those of the Russians or French at this period reached the middle of the northwestern coast of America, though many speculations and hypotheses were started by them. There remained an immense tract as little known in 1750 as it had been at the beginning of the seventeenth century. Before alluding to further operations, two enterprises of this period will be touched on, namely, the apocryphal discoveries of the so-called Admiral Fonte, and the expedition to California under the astronomer Chappe.

The so-called voyages and discoveries of Admiral Fonte have no historical foundation. Before the year 1708 no one had heard of such a person. Then it was for the first time mentioned that he had made important discoveries in the year 1640. When first told the story gained little attention, but in 1750 the two eminent French geographers De l'Isle and Buache declared their belief and brought the details before the Academy of France, and the story attracted much attention. Even the Spanish Jesuits in California occupied themselves towards the close of their tenure

with the subject. It seems proper, therefore, to mention it, which may be done briefly, as Venegas, the annalist of the Californian Jesuits, gives a treatise on De Fonte in his third volume.

Of De Fonte's pretended discoveries none but that of the Rio de los Reyes was ever deemed plausible.

In 1708, without signature or mention of authority, an English periodical, "The Monthly Miscellany or Memoirs of the Curious," contained an article entitled "A Narrative," in which a certain Admiral Bartolome de Fonte or Fuente relates that he was sent by order of the King of Spain and the Viceroy of Peru, in the year 1640, to make discoveries on the northwestern coast of America; that he had sailed in furtherance along the coast of California, and reached, at about 53 degrees north latitude, the mouth of a great river, which he named Rio de los Reyes, and opposite to this a large archipelago, which he called "San Lazaro." He further states that he entered the river and passing northeast discovered lakes, channels, and other waters, to each of which he gave a name, and at last leaving his vessel in one of the lakes he traveled overland to Hudson's Bay, where he found a ship from Boston in New England. The narrative adds that while De Fonte was on his extraordinary journey, one of his officers made at the north similar discoveries of channels, lakes, and passages from the Pacific into the northern waters, that he had given names to all of them, and described each of them minutely in his report to the Admiral.

The fiction here mentioned would not be worthy of notice if such intelligent men as T. N. de l'Isle and Philippe Buache had not brought the matter before the Academy of France, and declared their belief in its authenticity. English writers have made it probable that the story was furnished by Mr. James Petiver, the naturalist, whose taste and talents for such productions were well known. When eminent French geographers issued a map showing the pretended discoveries of De Fonte, of course they had imitators. Jefferys, Brouckner, and Bernouille, among others, adopted the whole or part, copied the map, and gave the names "Archipelago de San Lazaro," "Rio de los Reyes," and others, thus perpetuating the fable and promulgating it to the world.

1769.

The voyage of the astronomer, M. Chappe d'Auteroche, was one of several made to different parts of the globe for the purpose of observing the transit of Venus which occurred on the 3d of June, 1769. The French Academy was at the head of the enterprise, and wished to have observations made on one of the Spanish South Sea Islands, but permission being refused, the peninsula of California was chosen instead, and there the court of Spain was willing to lend a helping hand. So a combined expedition was arranged, of Spanish and French observers, and the direction was given to Chappe, who had previously made a voyage to Siberia in the interest of astronomy. For the observations of 1769 he was amply provided with astronomical and mathematical instruments, and he was accompanied by a French geographical engineer and a watchmaker. Two Spanish astronomers, M. Doz and M. Medina, joined him at Cadiz on his way to the New World.

The party expected to sail in one of the ships of the great Spanish fleet destined for Vera Cruz, but its departure being deferred from week to week, the time for the transit of Venus drew so near that a vessel was hastily made ready, and they sailed to Mexico and in a miserable condition landed on the 8th of March, 1769. With a caravan of mules the instruments were transported to the harbor of San Blas, and after long detention by calms and high winds the party reached the shore of the peninsula of California at a point near the mission of Saint Joseph, where, having some time left, they erected observatories in barns and under tents.

Favored by serene skies, M. Chappe had the good fortune to record a series of satisfactory observations on the transit and noted other astronomical phenomena, amongst which was a lunar eclipse and the immersion of one of Jupiter's satellites. All these and an interesting narrative of the expedition were made known to the scientific world by Cassini. The preparations of Chappe had been methodical, and his observations were made with scrupulous exactness. The Spanish astronomers pursued their operations separately. From all the observations the geographical position of San Joseph proved to be 23° 3′ 20″ N. and 112° 2′ 30″ west of Paris. But the best Mexican charts of that time varied much from this result, differing as much as three degrees in longitude and more than a degree in latitude.

According to calculations resulting from the observations of Chappe, Western America was found to be nearer to Europe than previous estimates by about four degrees of longitude. The result became a standard for all subsequent surveying operations. In 1793, when Vancouver finished his survey of the northwestern coast, he repaired to Cape San Lucas and the vicinity of Saint Joseph, in order to compare his results for position with those obtained by Chappe in 1769. While the last-named observer was engaged on the peninsula a malignant epidemic raged. He died there, as did several of his companions—his watchmaker and the Spanish astronomer, Don Salvador de Medina. In fact, the entire party of learned men assembled near Cape Saint Lucas became seriously ill. Those who recovered fled from the fatal shores, regardless of intended explorations for the benefit of geography and natural history.

The British Government sent out Captain Cook in the year 1768, accompanied by the astronomer Green and naturalist Solander, to observe the transit at a station on the island of Tahiti, and this was the first of a series of Pacific voyages which, ten years later, brought Cook to the northwestern coast of North America.

FRANCISCANS AND VANCOUVER, 1769–'92.

Fear of the progress of the Russians in the Pacific, the expulsion of the Jesuits from California, and the zeal in missionary work evinced by their successors, the Franciscan friars, awakened activity which was not again interrupted until the coast was thoroughly explored. Year after year one expedition followed another, European nations concurring, and at the end of the century nearly all the "mysteries of the west" lay open before the world.

Alarm at Russian progress had drawn the Spaniards to the northwest, and they had previously moved northeast (on the American continent) in consequence of the advances of the French. To check these in the valley of the Mississippi the Spanish sent expeditions which resulted in the settlement of western Texas. In 1762 they acquired from France the cession of the western half of the Mississippi country, and detachments of Spanish dragoons, missionaries, and tradesmen from New Mexico went sometimes as far north as the fiftieth parallel. At this time they seemed willing to take possession of a continent conferred on them by a Papal bull at the end of the fifteenth century. But this was merely as the last brightening of a flame before its extinction.

The Marquis de Croix, Viceroy of Mexico, who, in 1767, ordered the expulsion of the Jesuits from California, and gave their missions and settlements to the Franciscans, directed the latter to advance towards the northwest. Warmed by the triumph over their rivals, the Franciscans manifested great zeal. An enterprise was planned by their superior, Joseph de Galvez, with the approbation of the Viceroy, who was, however, succeeded in office by Don Antonio Maria de Bucarrelli in 1771, a man not less active in promoting geographical exploration and missions. By the exertions of these men was carried into effect, in the course of six or eight years, the long desired settlement, cultivation, and exploration of what the Jesuits had called the "*Contra Costa*."

The history of the labors and sufferings of the Franciscan friars and their companions is highly interesting. The aims and results at which they arrived served an important end in advancing the hydrography of the coast. Peaceful and comparatively strong, the missions became fulcrums of civilization in that region and desirable supports for subsequent northwestern voyages.

Spanish explorers returning exhausted, as also English, French, and other nationalities, relied on these establishments. Vancouver would probably have perished but for the succor afforded by the Franciscans in California, and the Russians relied on them for provisions. Agents of the Hudson Bay Company traveled from the Columbia River for supplies. In short, these missions were the basis of empire. Without them the United States would have found it much more difficult to establish government in that part of its territory. All American travelers in the beginning of the present century repaired to these hospitable settlements, as the mariners, the Russians, and the Canadians did, asking for bread and for succor when exhausted; and many doubtless would have perished if the Franciscans had not previously dotted the coast line with cultivated patches, cattle, peaceful Indians, and homes. It would be interesting to follow the history of these missions, but our main interest here relates to the land and sea expeditions by which they were established.

MISSIONS, 1769.

It was concerted between the Viceroy and the Superior of the Franciscan convents (José de Galvez) that three missions should be founded, one at San Diego, another at Monterey, and a third midway between the two, both of which had been pronounced by Vizcaino, a hundred and fifty years earlier, as well adapted for the intended purpose. The middle station was called San Buenaventura.

Two expeditions were to be sent out at the same time, one from the peninsula, by land, the other by sea from San Blas. Galvez himself superintended the arrangements for both. The land expedition was to conduct the principal missionaries with soldiers and cattle, lay out a road, and begin friendly intercourse with the Indian tribes on the way. This was under command of Don Gaspar de Portola, the captain of dragoons, who had been charged to expel the Jesuits from Lower California. He was supported by other officers, some soldiers, and several missionaries, under the supervision of Father Junipero Serra, who was constituted president of the new missions. They set out in two divisions, the smaller an exploring party under the conduct of Don Fernando Rivera and Moncada going in advance. The principal body, commanded by Portola, followed on the 15th of May, 1769, from the Mission de San Fernando en Velicata, the most northern settlement in Lower California. This had been founded only a short time before their departure. The track of the old Jesuit traveler, Father Wenceslaus Link, was followed to the neighborhood of the Colorado. From thence, taking a northwesterly direction, they arrived on the 1st of July, 1769, after forty-six days' travel, at the shore of a bay recognized by them as the harbor of San Diego, according to the old maps and charts, and there they found the sea expedition at anchor.

The sea expedition was intended to aid that on land by carrying out more soldiers, provisions, and implements. They were also to survey, or, as that operation was then expressed, "register the coast" (a tracer el registro de la Costa). For this purpose three ships were fitted out from San Blas: The San Carlos, San Antonio, and San Joseph. The principal vessel carried Don Vicente Vila, commander-in-chief of the expedition, and the second, Capt. Don Juaz Perez, who was afterwards one of the most active among the explorers and navigators of the northwestern coast.

The three ships sailed on separate days. Perez, in the San Antonio, arrived at San Diego Bay on the 11th of April. The San Carlos started more than a month earlier, but was a fortnight behind the San Antonio, the captain of the San Carlos, judging from "the indications of the old maps" that the port of San Diego was between 33° and 34° of latitude, but he found it at 32° 40′ He lost, therefore, much time, and did not discover his error until his crew was much wasted by sickness, hunger, and fatigue. Some of the crew died on this voyage. The third vessel (San Joseph) was never seen or heard of after sailing. The members of the two expeditions rejoiced in being united, but as a voyage to Monterey was out of the question, the San Antonio was manned, and Juan Perez sailed in that vessel on the 9th of July from San Diego southward to procure provisions and hands.

When the ships were found unavailable, and the San Antonio had sailed homeward, Portola determined to march northward, moving on the 14th of July, 1769, in search of Monterey. Part of the company was left at San Diego with Father Junipero Serra to form the intended settlement and mission and to negotiate with the surrounding Indians. He started with some soldiers and missionaries, including Friar Juan Crespi, the journalist of this and other Franciscan expeditions, and traveled slowly along the coast, accompanied by a train of mules and many friendly Indians. Passing the Sierra of Santa Lucia, they came in sight of the harbor of Monterey on the 1st of October. Men were sent to reconnoiter the bay, but could find nothing answering the description of the port of Monterey as given by the pilot, Cabrero Bueno, which was their only guide. The open bay they thought could scarcely be called a "port," and if Monterey was to be found they must look for it farther north. Portola was very anxious, as he hoped to find there the San Joseph, of the loss of which vessel he was yet ignorant. He therefore continued his march northward, though many of his followers were sick with scurvy; and thus "they turned their backs on the very port they were in search of."

On the last day of October they were within sight of the Farallones off San Francisco entrance, "the signs of which, being compared with the remarks of the pilot, Cabrero Bueno, were found to be exact." They were then convinced that they had left Monterey to southward, and on the 11th of November they turned in that direction and reached the bay, some of the party now believing it to be Monterey. There they remained until the 10th of December, waiting for the San Joseph, but no vessel arrived. The Sierra of Santa Lucia was already covered with snow, and Portola kept on towards the south. It seems probable that once during this expedition the party was on the shore of the harbor but could not identify the place. They arrived at San Diego on the 24th of January, 1770, after more than six months of travel and trouble, having been driven by hunger to eat their mules and horses on the way. Some of the party reported that the harbor of Monterey had probably been changed since the time of Vizcaino, as the spot so named on his map had been found filled with sand hills.

The ship San Antonio returned, as before related, to Mexico, and reached San Blas towards the end of July, 1769. From thence it was again dispatched, under command of Juan Perez, early in the year 1770, with provisions to Monterey, where it was supposed the land expedition had meanwhile arrived. But on touching at a point on the Santa Barbara channel to procure fresh water, Perez was told by the Indians that the expedition had gone back to San Diego, and having lost an anchor which he hoped might be replaced there, he was induced to steer for that harbor, and reached it on the 23d of March, barely in time to save the enterprise, as Portola and his party, destitute of any means of subsistence, had fixed upon that very day to go south and abandon the attempt at settlement.

When the two branches of the expedition united at San Diego with replenished means they agreed to set out again for Monterey. Perez sailed in the San Antonio on the 16th of April, 1770, accompanied by Father Junipero Serra. They were forced back by storms to the thirtieth parallel, where they found more favorable winds, and after six weeks of tedious navigation they entered Monterey on the 31st of May, being as far as we know the first Europeans who did so in a period of one hundred and sixty-seven years which elapsed after the visit of Vizcaino.

Portola and his party, including Father Crespi, the journalist of the expedition, left San Diego the day after the San Antonio sailed. They reached Monterey, where the vessel awaited them, and the reunited missionaries founded there the mission of San Carlos de Monterey, or the Royal Fort of San Carlos. Names were given at this time to some small rivers, valleys, and other places, but they are not all mentioned in the narrative of the expedition.

Early in August, 1770, the action at Monterey became known in Mexico, and the joy of the authorities there was such that they ordered a general ringing of the bells and a great festival. Mass was celebrated and a procession formed in which the Viceroy and all the tribunals joined. A proclamation was printed and distributed, giving a short description of the travels and discoveries of Portola and the missionaries, and announcing that the dominions of the King of Spain had been extended 300 leagues along the coast towards the north.

Perez had sailed from Monterey in the San Antonio on the 9th of July, 1770, to return to Mexico and bring from thence provisions. On reaching San Blas he gave intelligence of the proceedings at Monterey. From San Blas he was again sent, early in the year 1771, to Monterey, and there arrived with ten other missionaries on the 14th of April. On the 7th of July, 1771, he went to San Diego with dispatches, and from that place returned to San Blas with invalid missionaries.

Father Junipero Serra occupied the time after his arrival at Monterey by making excursions into the adjacent country, visiting Indian tribes, and seeking convenient sites for missions. Every mission thus founded was combined with previous explorations, and served also for extending geographical knowledge. Serra explored the valley of the Rio Carmelo near Monterey, and transferred to that valley his mission of San Carlos, the first position of which was further northeast. With other friars he visited the Sierra de Santa Lucia, and there settled the mission of San Antonio de Padua. He celebrated mass on the 14th of July, the day of San Buenaventura.

The mission of San Gabriel was established at the end of the summer of 1771.

Having somewhat advanced towards the south the chain of missions and settlements by which he intended to connect Mexico and Upper California, Father Junipero turned his attention to the

north. An expedition in that direction was agreed upon with the military commander Don Pedro Fages, who with some soldiers and the friar Crespi started from Monterey on the 20th of March, 1772. The latter wrote a journal of the expedition which shows that the enterprise was very unfortunate. Part of the country was surveyed, or "registered," when the work was interrupted by a report from San Diego of famine and sickness, and the contemplated abandonment of that port. The party consequently returned as soon as possible.

After returning with the invalids to San Blas at the end of the summer of 1771, Perez was again employed, early in the following year, to carry provisions to Monterey; but the bad condition of his ships and unfavorable weather made it impossible to attempt the passage around Point Conception. Instead, therefore, of making his destined port he carried the provisions to San Diego, which settlement, on the brink of ruin, was thus saved by him a second time. Information was sent to Father Serra in Monterey of the arrival of these supplies, and a request that they should be sent for by land, because of the difficulty and danger of water transportation; but the father, though now old and somewhat infirm, journeyed in person to the latter place and persuaded Perez to trust in God, notwithstanding the bad season, and attempt once more the voyage to Monterey, as the station must be abandoned unless the much needed provisions should soon arrive. Yielding to the promptings of Serra's faith and zeal, Perez again set sail, arrived in safety, and after landing his cargo returned to San Blas.

In 1772 Father Junipero founded the mission of San Luis Obispo de Tolosa at the south of Monterey; and after visiting the other missions resolved to return to Mexico for conference with the new Viceroy, Don Antonio Maria de Bucarelli, who had succeeded the Marquis de Croix, the former patron of Serra's enterprise, and who was supposed to be unacquainted with the importance of western missions and explorations. Junipero explained to the Viceroy the political importance of the missions, found ready audience, and procured all the aid desired.

Perez was sent out again with supplies, but his voyage was unfortunate. Driven by storms to the peninsula he was constrained to unload his vessels, and the friars and soldiers dependent on him for supplies elsewhere suffered greatly from hunger.

DON JUAN BAUTISTA ANZA. 1774.

At the request of Father Junipero, the Viceroy of Mexico had also sent an order to the commander of the northern frontier of Sonora to fit out an expedition for Monterey, and to trace an overland route in that direction, so that missions might not be entirely dependent on weather, communication with Mexico up to that time having been either by sea, around Cape San Lucas, or half way by land to Velicata and San Loretto in Lower California, and from thence by water.

Anza traveled with soldiers, cattle, mules, and provisions from Sonora to the Rio Colorado, crossed that river and went through the country to the coast, and thence to Monterey. He arrived in April, 1774, having on the way traced out a new land route between California and New Mexico through Sonora.

Partly at the suggestion of Father Junipero, the Viceroy was induced to furnish a larger expedition. The Santiago, a new ship, was fitted out and placed under the command of Juan Perez, bound to San Diego and Monterey, from whence the captain was to proceed to higher latitudes. In this ship, which sailed from San Blas on the 24th of January, 1774, Father Junipero returned to his mission. Landing at San Diego he traveled to Monterey, and arrived there on the 9th of May. On the road he met Anza, who was then on his return from Sonora. Perez also touched at Monterey and discharged supplies before going further north. His voyage to Nootka Sound was undertaken at the suggestion of Father Junipero Serra, and Perez was accompanied on it by two Franciscan friars, namely, Juan Crespi and Tomas de la Peña, so it may be considered as a branch of the Franciscan expeditions. Crespi and Peña jointly wrote an account, but no statement was ever made public by the Spanish Government. The particulars remained unknown during the last century. Some vague reports induced the insertion of the following remarks on maps: "The Spaniards are said to have made in 1774 an expedition as far as 55° N. L." Navarrete was the first who gave additional information in regard to this undertaking. The journal of Crespi and

Peña was made known to Humboldt in Mexico, and is mentioned in his Essai Politique, second edition, Paris, 1827, Vol. II, p. 296.

The founding of missions at San Diego and Monterey not only occasioned voyages, but contributed to their success. Mariners for such service were trained by associating with intelligent men, and the officers who commanded transports and provision ships also conducted explorations in the northern regions.

Perez after discharging his cargo at Monterey fitted his vessel for duty in high latitudes, and set sail for the north on the 6th of June. He seems to have taken at the outset a western course into the Pacific, but turned northward and again saw land in 53° 53′ north latitude, which, if the reckoning was true, must have been part of Queen Charlotte's Island. At 54½° north he reached a cape and an island, and to the last applied the name Santa Margarita.

What is known as Dixon's Strait was at a much earlier date called by Spaniards "*Entrada de Juan Perez.*"

On his way southward Perez saw various parts of the western coast, but his principal discovery was the harbor of San Lorenzo, in latitude 49° 30′ N., afterwards visited by Captain Cook and by him named Nootka Sound. Perez had some trade with the Indians, and Cook found traces in sundry articles of Spanish origin when he subsequently visited the place. The Spaniards doubtless saw some points of Vancouver's Island, and some writers suppose that at this time the entrance to De Fuca's Strait was first observed. What is now known as *Cape Flattery* was called formerly Punta Martinez, after the pilot of the San Antonio, whose name was Estavan José Martinez. On his way south Perez determined the latitude of Cape Mendocino, and arrived at Monterey on the 17th of August, 1774. He was soon afterwards again at San Blas.

This voyage may be considered fortunate, Queen Charlotte's and Vancouver's Islands being then for the first time touched on by Europeans. The Spanish Government kept long concealed the accounts and maps furnished by Perez, and subsequently English navigators were considered as discoverers of the places.

In the summer of 1774 Father Junipero Serra and the lately appointed military commander, Don Fernando Rivera y Moncada, started for the purpose of founding a mission on the shores of the Santa Barbara Channel. It was to be called San Juan Capistrano, and to be in charge of the Fathers Feronin Lazuen and Gregorio Amurrio, who were sent out at the end of October to explore the country. They selected a convenient spot and founded the mission, the name of which is still retained by a little port on the coast. The completion of the establishment was, however, delayed by an Indian revolt which broke out in the neighborhood of San Diego. This prevented further attempts for the settlement of missions by Father Junipero through the following year, 1775.

SONORA—SAN DIEGO. 1775.

A journey was made in 1775 by a Carmelite friar, Francisco Garces, and thereby another way of communication was opened towards the interior. Father Garces traveled from Sonora through the Colorado country, saw the southern end of the Sierra Nevada, and discovered in the interior of California, a river which he called Rio de San Felipe (perhaps the upper part of the San Joaquin), and passing on to San Diego he returned from thence to Sonora. Several journeys were made by the friar. This mention of his California excursion is in accordance with a map made by M. Mascaro, and in 1782 published in Arispe. The map has on it the route of Garces, as well as that of Don Juan Bautiste de Anza. This last-named traveler, after returning to Mexico, made in 1775 a second journey to California, taking with him soldiers and settlers, horses, mules, and cattle. On the 29th of September he set out from the Presidio San Miguel, in Sonora, and arrived at the mission of San Gabriel on the 4th of January, 1776.

NORTHWESTERN COAST, 1775.

Soon after the return of Perez, the viceroy of Mexico, Don Antonio de Bucarelli y Orsue, animated by this first success, ordered the fitting out of two vessels, the Santiago and the Sonora, for another expedition, which was put under command of Don Bruno de Heceta. He sailed in the

first named ship, and for the command of the second assigned Don Juan de Ayala, assisted by Don Juan Francisco de la Bodega y Quadra. Antonio Maurelle served as pilot and afterwards wrote an account of the expedition. Perez, who conducted the enterprise of 1774, as also some others, lost his life in this undertaking. Both of the ships sailed from San Blas on the 16th of March, 1775, with orders to proceed along the northwest coast as far as the sixty-fifth parallel if possible. On the first part of the voyage they were accompanied by the packet San Carlos, which vessel was bound to Monterey and San Francisco in charge of Don Miguel Maurique. But unfortunately that officer was seized with insanity a short time after he left San Blas. The command of his vessel was given to Ayala, and Bodega took the place of the latter in the Sonora. Thus Bodega became prominent in the expedition. Ayala, by taking the San Carlos into Monterey and San Francisco, was separated from it, and at that time made the first survey of the bay of San Francisco.

After separating from the San Carlos, the two remaining ships sailed to the northwest and had on board for information the history of California, by Venegas; also a map of the French geographer, Bellin, which "was found very unreliable and fanciful." They had also the chart made by their predecessor, Perez, who accompanied them on this voyage.

On the coast north of Mendocino they found a small harbor in 41° 07′ north latitude, which they entered on the 5th of June. In the course of a few days they surveyed the harbor, and erected a cross on the shore, and named the harbor Holy Trinity. A river emptying into it was called by them Rio de las Tortolas, or Pigeon River, from the large flocks of those birds seen there.

They sailed further north, looking as they went for the inlet marked on their map as De Fuca's Strait, and reached the coast in latitude 47° 24′ north, where a party from the crew of the Sonora was sent on shore for fresh water. They were attacked by the natives, and seven of the crew were killed. The savages appeared to be numerous; the landing was difficult; hence the murder was not avenged, and keeping on to the northwest the unfortunate spot was named Isla de Dolores. On some Spanish maps the place is marked as Ensenda de los Martires (Inlet of the Martyrs); and is probably the locality afterwards and even yet called Destruction Island.

On the 1st of August, and when in about 50 degrees north latitude, the ships separated in very thick weather. After seeking each other in vain, Bodega and Maurelle, in the Sonora, resolved to sail northward, but Heceta, in the Santiago, despairing of success, turned back to the southward.

In latitude 57° 04′ north, Bodega saw a high mountain, and named it San Jacinto. The same was afterwards called by Captain Cook Mount Edgecombe. In latitude 55° 30′ north a spacious bay was named, in honor of the viceroy of Mexico, Port Bucarelli. Other localities were at this time named by the Spanish explorers in this neighborhood, but they are now of no special interest. The highest latitude reached by Bodega was 58 degrees north. There his means were exhausted and he turned southward. On the 19th of September he was again in sight of the coast of California, in latitude 47 degrees north. Keeping on southward he reached an entrance in latitude 38° 18′ north, and supposed it to be San Francisco, but the great sea-mark, the Farallones, not being in view, his error became apparent to all in the party. A cape north of the port before him was called Punta de Arenas, and to the port itself was given the name Puerto de Bodega. It was now the 4th of October, and without entering at the Golden Gate, he passed on to Monterey.

The most interesting event of the expedition occurred on the return voyage. On the 16th of August Heceta saw the mouth of the Columbia River, but was unable to enter. Supposing it to be the mouth of some large river or strait, he called it the Bay of Assumption. On later maps it is named Entrada de Heceta, but on some Rio de San Roque, from the promontory north of it, to which Heceta had given the name San Roque. Both names are from the church calendar, that of the Assumption on the 15th of August and San Roque's the next day.

Heceta called the south cape of the inlet Cabo Frondoso, or Leafy Cape; but at this day it is known as Point Adams. He thought the opening might be the Strait of Juan de Fuca. Southward of this he saw another headland, and named it Cabo Falcon (now Cape Lookout), and continuing his course Heceta reached Monterey on the 30th of August. On the 7th of October he was joined there by the Sonora, and on the 20th of November both ships again anchored in the harbor of San Blas.

SAN FRANCISCO BAY, 1775.

The packet ship San Carlos, in charge of Don Juan de Ayala, a commander of the Royal Spanish Navy, after leaving provisions at Monterey for the uses of the missionaries, was directed to make a survey of the bay of San Francisco, for the convenience of other missions that by order of the Viceroy were soon to be founded.

Ayala arrived at Monterey on the 27th of June, 1775, discharged his cargo, and sailed promptly to determine (says Father Pal n) "whether the canal which had been imperfectly seen from a distance by the former land expedition was really an outlet to the sea or not." Nine days after leaving Monterey he found the outlet of the canal, which he called the Inlet of the Farallones; and the San Carlos passed safely through in the night. Thus, as far as can be now known, Ayala was the first European who entered San Francisco Bay. Perez in the preceding year had passed by, and the Franciscan friars on their land expedition, in 1769 and 1772, had merely seen the interior basin from the land side. Ayala reported the inlet of the Farallones as being "a Spanish league long and a quarter of a league broad, with strong currents issuing or entering, according to low or high water; and behind it a little Mediterranean Sea with two arms, one stretching 15 leagues to the southward, and the other 5 leagues to the north; and, again, beyond this he discovered the great bay 10 leagues broad, and another bay of a round figure [San Pablo Bay], into which empties the great Rio de Nuestro Padre San Francisco;" *i. e.*, the Sacramento River. Doubtless Karquines Strait was mistaken for the mouth of the Sacramento. He remained in the bay forty days exploring in a boat, and "registering" the large sheet of water. The Indians on shore seemed to be friendly.

After completing his "plan" of the bay, the entrance of which, according to his determination, was a few minutes below the 35th parallel, Ayala returned to Monterey, and reached port in the middle of September, 1775. Being asked whether the place visited was a good port, he replied that "it was not a port, but a cluster of ports," and that "many fleets could anchor there without seeing each other."

Ayala reported his researches to the Viceroy, and presented his map. As a result, great interest was awakened in Mexico, and activity in regard to settlements near a port having such manifest advantages.

Although this exploration by Ayala was one of the most important hydrographic achievements of the time, it was strangely overlooked by later historians. Navarrete does not mention it at all in reference to results, but merely says, "Ayala was the commander of the ship Felicidad (Sonora) and went with Heceta and Bodega to the north." Some writers record him as commander of that expedition. Greenhow corrects that error and states that Ayala had no concern with the northern expedition of Heceta and Bodega, having merely accompanied those explorers "a short distance from San Blas." But the last named writer does not mention the useful survey made by Ayala, which has been, as stated above, missed in the researches of historians generally.

The first land expedition from the south, which reached the bay of San Francisco, started from San Diego in 1769–'70. The second was undertaken in the following year, and proceeded from Monterey for the exploration of that body of water. The third expedition proceeded from the same place, and was conducted by Don Juan Bautista de Anza, who had made the journeys from Sonora to California.

On the 4th of January, 1776, Anza brought to Monterey the special order and instruction of the Viceroy for a survey of the bay of San Francisco, with a view of selecting the best sites for two missions, namely, one for San Francisco, and one at Santa Clara. In the following spring the service was performed. With the help of another officer and some soldiers a map was made from the land side, and positions were selected for the Presidio and missions. The party then returned to Mexico and reported to the Viceroy.

After his survey of the bay of San Francisco, Ayala returned in the San Carlos and arrived in Mexico at the end of the year 1775. Early in the following year the ship was dispatched to Monterey with provisions, and with it orders were sent for assisting in the foundation of the new missions. On the voyage the San Carlos was commanded by Don Fernando de Quiros, and arrived at

Monterey early in June, 1776, when Anza had just returned from his land expedition to the bay of San Francisco.

The land expedition, under command of Captain Don Josef Moraga, set out from Monterey on the 17th of June, accompanied by some Spanish families, soldiers, Indians, and cattle. The principal missionaries assigned to conduct the religious affairs of this northern station were, Father Thomas de la Peña, some of whose journals of the Franciscan expeditions are yet extant; Father Francisco Palon, who wrote a history of the missions; and the Father Pedro Benito Cambon. Some of the missionaries went with the land expedition, which reached its destination after a few weeks of travel, without any special difficulties. Others sailed in the San Carlos and were months on the voyage. By contrary winds the ship was driven back southward to the thirty-second parallel, and did not reach San Francisco until the 18th of August.

The parties began at once to build houses, magazines, forts, and chapels, and when the work was partly accomplished the commander of the San Carlos went out in a boat to explore the bay. He was on that occasion accompanied by Father Cambon. A small company was at the same time sent under command of Don Josef Moraga to walk around the bay, assist the boat party, and unite with it in the northeast at the mouth of the river.

On this occasion most of the points on San Francisco Bay received the names by which they are still known, as "San Pablo Bay," "Point San Pablo," "Point San Pedro," &c., but only a few are specially mentioned in the account of the expedition, and it is likely that they were named by Ayala. He was not, as Quiros was, attended by missionaries who would give religious names to places.

The land expedition went first to the southeast, passing around the shallow lagoon in which the bay of San Francisco terminates. At the southern end they found a river and called it "Rio de Notra Senora de Guadalupe." From thence going along the eastern shore of the lagoon until opposite to the harbor of San Francisco on the "Contra Costa," they saw in the mountains to the east an opening or valley which they thought might prove to be a short route to the point of rendezvous with the sea expedition, the mouth of the Sacramento River. In this, however, they were deceived. Losing their way, the party passed the mountains and came out upon a marshy plain crossed by several rivers, or river branches, and after traveling a short distance along what seemed to be the principal stream, they crossed it and marched northeast. But the plain seemed endless. They saw no inhabitants, and the heat was intense. The time for meeting the sea expedition passed by, and Moraga determined to return home. He thought that all the streams came from the southeast, and that their source was in the great "Tulares" (bullrush marshes) lying in that direction. It was the river Joachin along the lower reach of which they wandered—the first Europeans who saw its waters.

Captain Moraga and his company, on reaching the mission, gave an account of their journey. The boat party under Quiros advanced meanwhile to the northern part of the bay. They explored San Pablo Bay and entered the Strait of Karquines, which (as did also Ayala) they mistook for the mouth of the river Sacramento, and called it El Desembogue del Rio Grande. After it turned toward the east they found a port which had not been seen by Ayala. The same is now called Suisun Bay.

Father Palon, a witness of some of these events and the only historian who records them, does not say that the *mouth* of the Sacramento was reached on this occasion, or that a name was given to it. We may suppose that the party advanced as far as the junction of the Sacramento and San Joachin, or to what is now known as Sacramento Point. At this point the missionary, Father Cambon, "consecrated the waters," and the administration of the sacrament there suggested the name which was afterward applied to the river itself. On the map of San Francisco Bay, drawn at the time, the junction of the rivers, and also Sacramento Point, are accurately delineated, but no name is attached. Quiros explored the northern part of San Pablo Bay. On entering, he saw several small inlets and creeks, the largest of which he supposed might communicate with the ocean, but soon found "without any doubt" that the bay of San Francisco had only one outlet, and that the land on each side of the entrance formed peninsulas.

Quiros, in the San Carlos, returned to San Blas to report to the Viceroy, leaving Moraga and the missionaries to take care of themselves, construct their houses, till the ground, and civilize

the Indians. After this time Fernando Quiros served as an officer in the expedition under Arteago and Bodega in 1779, and was with them again in San Francisco Bay.

SANTA CLARA MISSION, 1776.

The successor of Portala in the military command of California was Don Pedro Fages. When that officer retired, in 1774, his place was filled by Don Fernando de Rivera Moncada, who, although concerned in plans for exploration, had not previously taken an active part for settlement and further discovery.

In the autumn of 1776 Rivera set out at the head of some troops to "register" the region in which it was desirable to found another mission, and marching north from Monterey across the plains of San Bernardino, he reached the southern end of the lagoon of San Francisco Bay at the river Guadalupe. The adjacent country was mapped by the party, and a site then selected for the mission was settled in January, 1777. On the same plain the Spanish village called El Pueblo de San Joseph de Guadalupe was founded, and names were assigned for the neighboring mountains and streams of water. In the following summer Don Felipe Neve became Governor of California, and founded the mission of Santa Clara.

1779.

The expedition of Heceta and Quadra in the year 1775 was considered successful, but it left some questions undecided, and amongst them the extent of the Russian settlements.

Bucarelli, Viceroy of Mexico and the court at Madrid, consequently decided upon another expedition, and two corvettes, La Princesa and La Favorita, were selected for the purpose. After much delay they sailed on the 11th of February, 1779. The command was given to Don Ignacio Arteaga, and Don Juan de la Bodega y Quadra. In the expedition of 1775 the last-named officer had command of a ship.

Sailing northward, the expedition of 1779 reached the latitude of Mount Saint Elias, after having made many observations along the coast between the fifty-sixth and the sixtieth parallels. Provided with Russian maps they advanced to the vicinity of Cook's River, where they seem to have been bewildered. According to La Perouse, the peninsula was supposed by them to be Kamtchatka, and an attack by Russian forces was dreaded. Moreover, many of the crew were sick. So, without reaching the seventieth parallel the vessels turned southward and entered San Blas on the 20th of November, 1779. An account of the voyage was written by Maurelle. La Perouse obtained a copy of the manuscript. The original is yet in the archives at Madrid, and a copy approved by Navarrete is in the library of the State Department, Washington, D. C., which contains also copies of several accounts of the same voyage.

Arteaga and Bodega as little knew of having been preceded in this voyage by Cook one year before as Cook did of the expedition previous to his own, made by Perez and Heceta.

In 1777 settlements extended as far north as the Bay of San Francisco. To the southward several links of the intended chain of establishments were not yet filled in. The coast of Santa Barbara channel had been only partially explored, though Father Junipero had long intended to found there three missions. Settlers, soldiers, and missionaries could not be immediately procured, but in the year 1777 orders were given in Mexico to recruit for that object, and about one hundred persons started for California under the direction of Don Fernando Rivera. Some delays occurred, but in the spring of 1782 Father Serra left Monterey and traveled south along the coast to the mission of San Gabriel. He there consulted with Don Felipe Neve, who had arrived as Governor in 1777, and they decided that the mission of Buenaventura should be at the eastern extremity of the channel; that of Purisima Concepcion at the western end, and Santa Barbara between the two. On the 26th of March they started from San Gabriel, and were traveling when the Governor was recalled by urgent business. Serra kept on, however, to a site called, (Palon says) since the first expedition in 1769, Assumpta, or Asuncion de Nuestra Señora, where he found an Indian village in latitude 34° 13′ N.; and by erecting some houses and a chapel he founded the mission of San Buenaventura.

Neve rejoined the expedition, and leaving some soldiers to protect the new establishment, he marched westward towards the coast, attended by Father Serra. The shore was "registered" (*i. e.*, mapped), and was closely examined with reference to facility for anchorage. Ten leagues from San Buenaventura they found a small bay, which seemed to promise good anchorage, and on the shore they erected a cross and built a small Presidio or fort.

The Governor judged that the mission could not be safely established until the fort was complete. He therefore returned to San Diego, and Serra to Monterey. Some soldiers and a priest were left at the station, which they named Santa Barbara.

In the following year Serra journeyed to San Gabriel, San Buenaventura, San Luis, and other stations, and made a tour of inspection to the northern missions, near San Francisco Bay. In the following year, 1784, the venerable missionary died at the mission of San Carlos de Monterey, and was buried there. With him the progress of exploration and settlement in California seems to have ceased, but at intervals some villages and missions were subsequently founded. It had been in contemplation to form an establishment at the harbor of Trinidad (discovered by Heceta in 1775), but that purpose was never accomplished. Of the persons enlisted in this work, several died about the same time. Don Juan Perez, the pilot, a personal friend of Serra and assistant in his land excursions, ended his days in 1775, soon after his return from the far north with Heceta and Bodega.

Father Juan Crespi, the associate of Father Serra in many labors and journeys, and author of some valuable journals, died in California in 1782; and in the same year Father Garces, after opening a way from the Colorado country to the westward, was killed by the Indians. Don Antonio Bucarelli, the Viceroy who had liberally assisted the Franciscans, died in 1779, and his successors were not energetic men.

The American Revolution, in which were involved in the interest of the colonies both France and Spain as against Great Britain, interrupted the series of Spanish undertakings and turned the attention of the court of Madrid to the east. It was decided that there should be no other expeditions started for America until peace was restored.

The scientific and commercial world for a long period derived no benefit from the early Spanish voyages to the northwest. All records of them being retained by the court and the Viceroy of Mexico, the public knew only of the departure, from time to time, of the companies as they were sent out.

CAPTAIN JAMES COOK, 1778.

After Anson's voyage, in 1741, English navigators had appeared at intervals in the Pacific. Wallis, Byron, and others traversed the waters along the equator and south of it, but the enterprising Captain Cook extended navigation to higher latitudes.

In 1769 Cook was near Otaheite and New Zealand. In 1772 he again entered the South Sea, and it was easy to forecast that the British would soon reach the northwest coast of America, where they had not been since the time of Sir Francis Drake (in 1578). But the coast had been remembered by them under the name New Albion, which on this map was intended to include the whole of Upper California. Spaniards, also, extended their pretensions, and some of their authors claimed rights that would be limited only by impassable ice towards the North Pole.

Captain Cook had viewed the icy barrier near the South Pole, but in 1776 he turned northward and was commissioned to discover whether any passage for ships was practicable between the Pacific and the Atlantic waters. Other officers were at the same time sent for the same object to Baffin's Bay. It was not supposed that any passage could be in less than 68 degrees of latitude, as Hearne, an English traveler, had found the land continuous below that parallel. Cook was therefore directed to winter at the Sandwich Islands, and proceed from thence in the spring of 1778 as directly as possible to the coast of New Albion, and to refit, if needful, in some harbor there. He was then to gain the sixty-fifth parallel, "taking care not to lose time in exploring rivers or inlets or upon any other account until he should get in the before-mentioned latitude."

Some distance north of Cape Mendocino the coast was seen on the 7th of March, 1778, and as determined by chronometer reckoning the longitude was 235° 20′ east. The latitude by observation was 44° 33′ north. Weather being unfavorable he named the cape first seen from his vessel Cape

Foulweather, which he supposed to be in latitude 44° 55′ and longitude 235° 54′ east. He stood for some time to the northwest, but making no progress and finding no harbor the course was changed to southwest. After recording lunar observations he reduced seventy-two sets of observations which had been previously made "with the time-keeper" in the course of three weeks, and these gave a mean result of 235° 15′ 26″ east for the longitude. That determination was adopted, and was applied as a check in marking on the chart all other positions along the coast.

On the 7th of March Cook was near a cape which he named Cape Perpetua, and five days after approached another, and called it Cape Gregory. He saw no more of the coast, as a storm drove his vessel southward and westward into the open sea, where an observation gave for the latitude 42° 45′ north. Favored soon with better winds and steering northeast the coast was seen again in 47° 05′, and continuing on that general course it seems probable that he approached the vicinity of Destruction Island. The extremity of the land which he saw was named Cape Flattery, because he hoped to find a harbor near it, but found none. Hence Cook did not enter the Strait of Fuca, but recorded the geographical position of the cape, or more probably that of Flattery Rocks. If somewhat southwest of those rocks he could not well see the mouth of the strait. On charts of the British Admiralty, the Flattery Rocks are named Cape Flattery, and the name of the cape on them bears the designation given by Vancouver, namely, Cape Classet. With varying winds Cook stood out from the cape, first to the south, then west-northwest, and finally northeast, and on that course he reached land on the 29th of March in latitude 49° 29′ north. The cape in view he called Woody Point, and a projection southwest of it he named Point Breakers. A bight between the heads he designated Hope Bay, because he expected to find there a harbor, and so it proved. He ran into the bay on the 1st of April, moored his ships, and remained several weeks, occupied in making repairs, taking in wood and water, in recording astronomical observations, and in conferences with the natives of the region, which he thought was part of the continent. When repairs were complete, Cook set out on the 20th of April in boats to view the sound, and on the sketch he marked it King George's Sound, but he soon ascertained that by the inhabitants it was known as Nootka. In books and maps after Cook's time both of the names were applied, but ultimately the Indian appellation alone was used.

Amongst the aborigines Cook found some iron tools, and copper and brass implements. These, and two silver spoons mentioned in his narrative, probably had been left by the Spanish expedition of Perez in 1774, but, having no knowledge of that, possession was taken of the harbor and surrounding country in the name of the King of Great Britain. Earlier, Perez had done the same for the King of Spain, and out of this and similar events arose controversies and discussions between the two powers.

Cook left Nootka on the 26th of April, and passed some time in examinations further north. He traced the coast of Russian America, and soon after was killed in a dispute with savages at the Sandwich Islands. His successor in command, Capt. Charles Clerke, after another attempt to find a passage through the northern region of America, reached Kamtchatka with an exhausted crew, and from thence the vessel proceeded to Canton in command of Lieutenant Gore, Clerke having died of consumption on the 22d of August, 1779. At Canton the sea-otter skins obtained of the Indians for a few buttons and scraps of iron, were sold for \$60, and in some cases for \$100 each. "It is astonishing," says La Perouse, "that the Spaniards who had this article in such abundance on the Californian coast, and who were for two hundred years in active commercial communication with China, should not have found out its value; furs having been for a long period procured by the Chinese from the coast of Kamtchatka." In fact, the statement by Captain Cook in regard to sea-otter skins, moved the commercial and seafaring world more than his geographical developments. The mention of them in the history of his voyage (published in 1784) excited a strong spirit of enterprise, and induced "a general starting for the northwest," as there once had been for the silver mines of Peru and Mexico. All maritime nations were incited to action, and from 1785 until 1793 followed a series of private and public expeditions which, in less than ten years, made the northwest coast of America well known, though it had been a mystery during three centuries. Vancouver's voyage completed the development; but all others were of interest. Even trading voyages were dignified by descriptions, and details were published, because they related to countries comparatively unknown. Each navigator brought home addi-

tional information, knowledge, and name of a promontory, channel, inlet, island, or previously unknown part of the coast, and the particulars were speedily translated into all the languages of Europe.

LA PÉROUSE, 1786.

Francois Galoup de la Pérouse sailed from Brest on the 1st of August, 1785, with two ships, La Boussole and L'Astrolabe, and after touching at the Sandwich Islands reached the northwest coast of America on the 23d of June, 1786. When Mount Saint Elias was in view, he turned southward and sailed as far as Monterey, in a direction different from that prescribed by his instructions, in which the special objects mentioned were the exploration of the coasts of China, Japan, Tartary, and Kamtchatka. But as the trade winds there did not set in earlier than February, some time was given for the examination of the Pacific coast. Until the 3d of August the vessels were detained by several accidents at a port which La Pérouse called Bay des Francois. He reached Nootka on the 24th of August, and as the weather was very foggy, it is certain that little was done for geographical definition. At the Strait of Fuca he did not see the entrance, but in the offing took soundings and found "a bank of rounded pebbles at the depth of 40 fathoms." This is marked on his map, and in the narrative is described as being 150 feet high, 1 league wide, and of indefinite length. On the 1st of September La Pérouse was off the coast a short distance southward of Cape Flattery, and surveyed from thence down to the forty-fifth parallel, and had several opportunities for observing latitude and longitude. This stretch of the coast had not been examined by Captain Cook.

At Cape Blanco or Orford, the French navigator saw the rocks which stretch out to the southwest, and named them Isles Necker, and subsequently he applied the same name to two groups of South Sea islands. In all other instances La Pérouse adopted for his charts the Spanish names, or those given by Cook. The French vessels sailing amidst fogs arrived at Monterey on the 15th of September, and there observations were made for geographical position. On the 24th of that month La Pérouse started on his voyage across the Pacific Ocean. A comparison between his charts and those of Vancouver (only six years later) shows that the French navigator had no opportunity to advance knowledge in the hydrography of that region. Still, his observations would have been valuable, if they could have been made known to the world promptly; but the unfortunate fate of that accomplished navigator delayed the publication of results until the year 1797. Vancouver and others had meanwhile laid open to the world the secrets of the Pacific coast; and thus it happened that even the few names affixed by La Pérouse to localities on our northwestern coast were not adopted by geographers, and are now seen only in the journals of his voyage. His charts were constructed under the direction of the astronomer Dagelet, member of the Academy of France.

1785–1787.

The resorts of fur-bearing animals became objects of much interest soon after the time of Captain Cook. In the higher latitudes the skin of the sea otter was worth much, but along the coast of California those animals became scarce, and the furs were less valuable. Prompted by interest, several expeditions went to the northwestern coast, and after touching at points south of it, they finally selected Nootka Sound as a recruiting station. But of many voyages, only such will be mentioned as tended to improve the knowledge previously gained respecting the western coast.

The first fur hunting expedition was conducted by Captain Hanna, of England, who sailed in 1785 from Canton to Nootka Sound. Cook had made his best barters in the last-mentioned place; and there Hanna collected many skins and sold them at large prices in Canton. In the year following he made another voyage for trade, but it added nothing in the way of geographical development. So also of the voyages in 1786 by Captains Peters, Lowrie, and Guise, from Canton and Bombay. Peters was wrecked on one of the Aleutian Islands, but the others reached their destination, procured furs, and sold them in China.

Captains Meares and Tipping in the year last mentioned were unfortunate. The first was

frozen up in Prince William's Sound, and lost many of his crew. Tipping, with his vessel, was lost, and was never heard of again. In 1788–'89 Meares made two successful voyages.

In 1785 an association of London merchants, under the name of King George's or Nootka Sound Company, sent two ships to the North Pacific. One of the vessels, the Queen Charlotte, was commanded by Capt. George Dixon; the other, King George, was in charge of Capt. Nathaniel Portlock. Both of these officers had served under the celebrated navigator, Cook, and by him were regarded as able men. They reached the northwestern coast in the summer of 1786; and there traded and made explorations, and wintered at the Sandwich Islands. Dixon returned to the northwest, and named several places. As the chief result of his voyage, may be mentioned the circumnavigation of the large island named after his ship, Queen Charlotte's. He proved that it was separated from Vancouver's Island, as well as from the continent of America; and to the dividing channel he gave the name Dixon's Strait.

The fur-trading adventurers sailed under different flags, to avoid collision with English and East India companies. Some used the Portuguese, and one, Captain Berkeley, sailed from Ostend, in 1787, in the ship Imperial Eagle, on which he carried the Austrian flag. This voyage was the first one made from Nootka Sound to the southward along the coast of California. At Vancouver Island, Berkeley anchored at an inlet for trade, and marked it on the map with his own name, but it is now known as Natinat Sound. A boat was sent to Cape Flattery, and after landing near an Indian village named Classet, went on southward, but previously a yawl had been manned to examine the mouth of a great inlet. On landing the crew was attacked by Indians and murdered, and that untoward event was commemorated by naming the place Destruction Isle. It is probably the same island that in 1775 was named by Heceta "Isla de Dolores." Berkeley sailed to the Sandwich Islands, and from thence to China.

CAPTAIN JOHN MEARES, 1788.

The narrative published at London in 1790 is accompanied by two charts—one of the North Pacific Ocean, the other of the northwestern coast of America.

Meares made several voyages from Calcutta after the beginning of the year 1786. In 1788 he was again with his ships, the Felice and the Iphigenia, in King George's Sound (Nootka), and there built a trading-post. While so engaged he was visited by an Indian chief from the south of Vancouver's Island, and was invited to the settlement of the tribe at the Bay of Clayaquot. On the 11th of June Meares sailed in the Felice from Nootka, where he left part of his company employed in erecting buildings. Captain Douglas, in the Iphigenia, was directed to trace the coast to the north between Cook's River and Nootka, while Meares went southward.

At Clayaquot Sound, he anchored in a harbor which he called Port Cox; and passing Berkeley's or Natinat Sound, he had, on the 29th of June, in clear weather an inlet in view, bearing east-southeast with unbroken horizon towards the east. He sailed over to the land south of the entrance of this inlet, which he thought to be the one described by Captain Berkeley in the preceding year, and then named John de Fuca Strait. At page 156 of the printed narrative, Meares gives a large view of the entrance. Near Cape Flattery the vessel was moored, with the intention of exploring with boats to the eastward. Tatooche, an Indian chief, then ruled in the vicinity of the island which is known now as Tatoosh Island. Meares saw on the coast a village named by Berkeley, and from that the headland (Cape Classet) was named by Vancouver. Going southward Meares saw Destruction Island, where the men of the ship Imperial Eagle had been killed by the savages. The bay north of this he calls Queenbithe, the name given by Berkeley; and south of it a projecting part of the coast he named Saddle Hill.

A large snow-clad mountain seen at the northeast was named by Meares Mount Olympus. The Spanish navigator Perez saw it in the year 1774 and named it Cerro de Santa Rosalia. Meares passed the entrance of Gray's Harbor without seeing it, but on the 5th of July, he discovered from a distance a similar body of water and named it Shoalwater Bay, because the soundings decreased very much in its vicinity. From the masthead the bay was seen extending inland, and made up of several branches, and inland the bay was bounded by mountains. At the entrance the northern cape was named Cape Shoalwater, the southern he called Low Point. Some land was seen to the southward,

and he hoped it might be the Cape Saint Roc of the Spaniards behind which Heceta was said to have found a harbor. As he rounded the promontory a large bay seemed to open, but when he tried to enter, shoal water was met, surrounded by breakers, and as soon as possible the ship hauled out again. In consequence of this (says Meares), being now convinced that there was no inlet or approachable port, the bay was named Deception Bay, and the promontory Cape Disappointment, which headland is the Cape Saint Roque of some Spanish maps, and now Cape Hancock on charts of the Coast Survey. This was on the 6th of July, and Meares then believed himself able to assert that there existed no such river at all as that of Saint Roc. Steering on farther south he saw two headlands and between them a bay formed by the receding coast. To the northern headland (now Tillamook Head) he gave the name of Cape Grenville, and to the southern, seen from a distance, that of Cape Lookout. The intervening body of water he called Quicksand Bay. The rocks seaward of Cape Lookout were named the Three Brothers. In his published work Meares gives a view of the cape and its rocks, and among the latter appears the perforated rock now so well known to mariners who pass along the coast. Cape Lookout was the southern limit of the exploration by Meares. Feeling uneasy in regard to the safety of the people left at Nootka, he turned northward and in the course of his voyage entered the sound near Vancouver Island. It was known as Berkeley Sound after the year 1787, but it is now known as Natinat. There he found a harbor, named it Port Effingham, and performed the ceremony of taking possession of the Strait of Juan de Fuca in the name of the King of Great Britain. From thence the long boat was dispatched in charge of Mr. Robert Duffin to explore the strait. Duffin left on the 13th of July, but returned to Port Effingham on the 20th of the same month. Meares says that after advancing nearly 30 leagues up the strait, Duffin entered a port or harbor from which "he observed that the strait to the northeast appeared to be of great extent, and that it increased." Meares has Port Duffin on his map in the position now occupied on charts by San Juan, or Poverty Cove. In that neighborhood Duffin was attacked by the natives, who wounded some of his men, and as soon as possible the little party, in consequence, returned to Port Effingham. Meares decided to return to the party which had been left at King George's Sound; and after an absence of nearly two months he again anchored in Friendly Cove, at Nootka.

Soon after his return to England Captain Meares published an account of his explorations of 1790, and added what had been told to him of the American Captain Gray, whom Meares had met at Nootka in 1788. Meares was informed that Gray sailed in the ship Washington, in the year 1789, to the Strait of Fuca, and there entered an extensive inland sea. After sailing in it eastward, north, and northwestward, he had come out upon the Pacific at the north of Queen Charlotte's Island, thus proving that the land between Fuca Strait and the fifty-fifth degree of north latitude was merely a group of islands. Confused by these statements, Meares declared in his published work in 1790 that the discovery of a northwestern passage (around the continent of North America) was a reasonable supposition. Captain Gray gave to Vancouver a true account of his voyage, and stated that he had seen very little of De Fuca's strait.

Many geographers in Europe hailed the exaggerated report of Meares, and the fables of Admiral De Fonte respecting a great northern inland sea and water communication between the Pacific Ocean and Hudson's Bay were revived. Fleurieu, the French author and minister of marine; Forster, the German historian of the northwest, and others adopted as a fact in geography "the great open sea discovered by the American ship Washington." Some called it simply "la mer de l'Ouest," and others recalled the fabulous name "Archipelago of Saint Lazaro," given by De Fonte. On some maps the route of Captain Gray was laid down as running through the middle of an archipelago on a dotted line upwards of 600 miles in length. Vancouver reduced that fantastic sea to its proper size. But, as late as the sixth year of the French Republic, the geographer Fleurieu could not consent to give up the "mer interieure." Like the two Buaches, he continued to foster belief in the authenticity of the romance of Admiral De Fonte, and he blames the map-maker, Arrowsmith, because on his map of 1794 the sea was not introduced, which, as Fleurieu declared, "would no doubt lead to much more important discoveries, and perhaps open or at least facilitate the long-wished-for communication with the eastern ocean."

A few years preceding the French revolution, English fur-traders went to the northwest, and from France the navigator La Pérouse passed into the Pacific. He was soon followed (in 1791)

by a private expedition, conducted by Marchand, and the Government of the United States ordered that exploration should be made in the South Sea. Spain also, which for ten years had discontinued her northwestern expeditions, renewed action, and in 1788 sent out several parties. These were partly contemporaneous with Vancouver. The Spanish parties were commanded by Don Estavan Martinez and Don Gonzalo Lopez de Haro, who sailed, in the ships La Princesa and San Carlos, on the 8th of March, bound from San Blas to the north to examine the vicinity of the Russian settlements. An account of this expedition is given by Navarrete; and Humboldt found in Mexico a large manuscript relating to the voyage. The same vessels were sent north in 1789, and on the 6th of May Martinez reached his destination, and seeing some foreign vessels, made known to their commanders that he had come to take possession of Nootka and the surrounding country in the name of the King of Spain. He erected a small fort, mounted artillery, and sought communication with Macuina, the Indian chief of the region, who had been during ten years well known to northwestern navigators. The chief remembered the visit of Martinez fourteen years earlier, when he was on the coast with Perez.

Macuina is styled by Humboldt the "Montezuma of the northwest." To him and his people Martinez declared that his King was sovereign everywhere in America, and that without his permission none could trade, navigate, or settle there. He inspected the papers of all foreign captains. Those of an American and of a Portuguese vessel were admitted as valid, and they were allowed to trade; but the ship of an Englishman, Captain Colnet, was seized, and he was sent a prisoner to Mexico.

The mission of Martinez was in fact merely political, yet it included some further exploration of the vicinity of Nootka and of the channel which separates it from Vancouver Island. For the port itself he adopted the name of Puerto de Santa Cruz de Nutka.

STRAIT OF FUCA, 1789.

When Martinez was at the north with Perez in 1774 he had noticed an opening which he supposed to be a strait, and having now the control of means its exploration was undertaken. He accordingly built at Nootka a small galley, the Gertrudio, and put it under command of Don Lopez de Haro, who had been with him in his preceding voyage. That officer sailed along the southwestern shore of Vancouver Island, and after entering the Strait of Fuca turned and examined the southeastern end of the island, but want of provisions and bad weather constrained him to return to Nootka.

This enterprise of De Haro was conducted under special instructions. The result is given in the journal of the Sutil and Mexicana, and the author gives a sketch of previous expeditions for the exploration of the strait, mentioning the ship Gertrudis as commissioned by Martinez; but he does not name Haro as the commander. It is also noticed in Quimper's manuscript journal, a copy of which, approved by Navarrete, is in the library of the State Department in Washington City, D. C. That journal mentions the vessel as under command of De Haro. It is believed, therefore, that M. Duflot de Mofras is in error when he says that Don José Narvaez was commander of this expedition in the Gertrudis. The memory of Narvaez may have failed him, as he was at least eighty years old when he met De Mofras in Mexico in the year 1842. Narvaez had been a very active officer. He accompanied Elisa in 1791, and it is therefore possible that he was with De Haro in 1789.

When the British Government protested at Madrid against the treatment of Captain Colnet, the Viceroy of Mexico deprived Martinez of his command, and ordered him to return home by the end of the year 1789, but at the same time three armed vessels were sent to the northwest under the command of Don Francisco Elisa and Don Salvador Fidalgo, to take possession of Nootka for the King of Spain. This expedition reached its destination in March, 1790. Elisa remained to fortify and enlarge the establishment at Nootka, while Fidalgo made a voyage of discovery to the north. In the course of the year he viewed the Russian establishments as other Spaniards had done, and entered on his maps some names which have not been retained. At the close of the year he returned to Monterey, and from thence to San Blas.

DON MANUEL QUIMPER, 1790.

Quimper sailed from Nootka in the balandra La Princesa Real on the 31st of May, and passed along the southwestern shore of Vancouver Island, exploring on his way Clayaquot Sound. He anchored in the Bahia de San Rafael, and subsequently in the port of Cayuela, which he says was so named by Lopez de Haro the year before. Quimper reconnoitered Clayaquot Sound and made a map of it, but did not examine its numerous inlets and branches. He then entered the Strait of Fuca, coasted along the southern shore, and anchored at the harbor of Nuñez Gaona (Nee-ah Harbor), and took possession in the name of the King of Spain. The document in which an account is given of this interesting ceremony is signed by Quimper himself, and his two pilots, Don Gonzalo de Haro and Don Juan Carrasco.

Proceeding easterly to the port called by him Puerto Quadra, but afterwards named by Vancouver (in 1792) Port Discovery, Quimper steered to the northwest and north until he reached the strait called La Boca de Haro, and that name (Mouth of Haro) he mentions as if already known. He looked into the passage but was unable to explore it, as his means were exhausted. For the same reason Quimper says "we could not explore the other small inlets or harbors which we saw at the western entrance of De Haro Strait." Many years afterwards these were named by the English Peddler Bay and Becher Bay.

MALASPINA, 1791.

The Italian navigator Malaspina was noted for scientific acquirements and discoveries, and his career was marked by misfortune. Like Captain Cook and La Pérouse, he engaged in geographical explorations, of which the northwest coast of America was merely one branch. In 1789 he sailed from Cadiz with two well appointed vessels, La Descubierta and Atrevida, and, after reaching the Rio de la Plata, made a careful survey of the coast of South America, from thence into the Pacific, and as far north as Mexico. Malaspina arrived at Acapulco on the 2d of February, 1791. By direction he was to proceed north, survey the coast, and seek for a passage into Hudson's Bay, as that was still regarded as an unsettled question. The well-known geographer T. N. Buache had in the previous year read a memoir before the Academy of France, in which he attempted to prove that the old fable of Maldonado's discovery of a strait at the north "was founded on reason, nature, and probability." Another of the name had believed in the fictitious narrative of De Fonte. It seems likely that some account of the statement by Meares respecting a northern Archipelago, through which the American sloop Washington was said to have sailed, had reached the court of Spain.

Malaspina left Acapulco on the 1st of May, 1791, and sailed northward as far as the latitude of Mount Saint Elias. He saw no indication of Maldonado's strait, but having instruments and knowledge of methods of observation (as stated by Humboldt) he determined longitude and latitude at many points more accurately than had ever been previously done. The height of Mount Saint Elias and the height of Mount Fairweather were approximately ascertained and magnetic observations were recorded.

Touching at Nootka on his return, Malaspina erected an astronomical observatory and determined the geographical position of the place. Two of his officers, Don Joseph de Espinosa and Don Ciriaco Cevallos, were sent in boats to survey the islands and channels of that locality. They found that Nootka was on an island, and passing around it they came out upon the sea by a channel since known as Esperanza Inlet.

Malaspina was not able to explore the Strait of Fuca, but from Cape Mendocino he passed, with the coast in view, down to Cape San Lucas, frequently recording observations for the construction of his chart. No previous expedition had afforded data for defining the shore line with such accuracy. His records were deposited in the Spanish archives, and ultimately he became the victim of court intrigues. In a dungeon he languished many years, and was at last released by the French. His name seemed to be forgotten in Spain, as, with the appearance of studied malice, his expedition to the Pacific was alluded to by Spanish writers as having been made by the ships Descubierta and Atrevida. The learned author Navarrete, in his history of

the northwestern coast, does not mention Malaspina, but sometimes refers to him as the "commandant," &c. But in time most of the works of Malaspina were published, and upon the results of his observations (says Humboldt) are founded all the Spanish sea charts of America made since the year 1799. Previous representations are of value only as documents pertaining to the history of discovery and development.

The commander at Nootka, Don Francisco Elisa, went out in the summer of the year 1791 to clear up uncertainties respecting the Strait of Fuca, some doubts having arisen in regard to the report given by Quimper who had been there in the previous year. Like some others this voyage of Elisa has been neglected or overlooked by most writers. There seems to be only one source of information in regard to it, namely, the journal of Galiano and Valdez, on the second page of which is given a short account of the undertaking, and in the narrative are mentioned special points, the capes and bays mentioned by Elisa, with the names which he assigned to them. He sailed from Nootka in May, 1791, and until the 7th of August was engaged in exploring the Strait of Fuca and Rosario Strait. Advancing further than his predecessors, he passed the entrance of Admiralty Inlet (Bocas del Coamaño), Deception Sound (Entrada de Flow), and sailed through what is now called Rosario Strait. He discovered and named several islands, and entered Bellingham Bay, which he called "Seno de Gaston." Elisa was the first European who entered the Gulf of Georgia, and to it he gave the name Canal de Nuestra Señora del Rosario. Advancing as far as Frazer's River entrance and Buzzard's Inlet, he named the latter Canal de Florida Blanco, in honor of the Spanish minister. He went no further, but seems to have had some distant capes in view. His means were exhausted, most of his crew were sick, and himself so ill that one of his officers, Don Joseph Narvaez, was in the latter part of the voyage the active commander. It was Narvaez also who compiled the maps of the expedition, and these circumstances perhaps explain his assertion made to De Mofras when they met in Mexico, that he had himself explored the Strait of Fuca and Rosario Strait in 1791. But he had boasted of this as early as 1789, when he was, perhaps, there under the command of De Haro.

MARCHAND, 1791.

Etienne Marchand was captain of a French merchant vessel trading to the East Indies when (in 1788) returning from Bengal he met at St. Helena, with Captain Portlock, an Englishman, who told him of the very profitable fur trade then commencing on the northwest coast of America. On his arrival at Marseilles, Marchand made the facts known to the house of Baux, a wealthy and enterprising commercial firm, who at once fitted out the ship Le Solide and gave the command to Captain Marchand. A staff of eleven officers joined him, and preparations were made to enable the party to make discoveries as well as to carry on trade. They sailed from Marseilles in December, 1790, four years after La Pérouse, and on the 12th of August, 1791, arrived at Norfolk Bay, called by the Spaniards Baya de Guadalupe, and by the Russians, Sitka Sound. Somewhat disappointed with the results of commercial transactions, Marchand passed along the coast southeast, and examined points of land, ports, and bays on Queen Charlotte's Island and in its vicinity; but all of these had been previously visited by La Pérouse, and by some of the English navigators. After some attempts at trade Marchand went further south, intending to enter Berkeley Sound on Vancouver Island, and from thence, if practicable, go as far south as Cape Mendocino.

Marchand anchored off Berkeley Sound on the 7th of September, but was prevented from entering by threatening weather. While making ready on the following day, he saw a three-masted vessel coming out of the port, which he concluded had taken all the furs that were previously there. He noticed that the strange vessel (an American ship) took the course which he had intended to pursue towards the coast of New Albion and Cape Mendocino. Hence, being anxious to get the highest price for his cargo, he sailed for China. Fleurien regards it as improbable that Marchand saw even the entrance of the Strait of Fuca.

VANCOUVER, 1792–'95.

In the period of fourteen years after the expedition of Captain James Cook no party was sent from England to the Pacific Ocean. A voyage, however, was planned in 1789 for exploring

some of the southern regions, and Captain Henry Roberts, a friend of Cook, was invited to take command. Captain George Vancouver, associated with Cook in his last voyage, was urged by Roberts to accept place as his second, and the ship Discovery was fitted out for them.

Not long before the vessel was ready for sea (April, 1790) it became known that the English factories at Nootka and the English ship of Captain Colnet had been seized by the Spaniards. The ship "Discovery" was in consequence provided with an armament; and the preparation of a formidable English fleet induced the court of Spain to offer restitution. In July an officer was sent to Nootka "to receive back the territory which the Spaniards had seized." George Vancouver was appointed for that duty.

The attention of the British Government being thus drawn to the northwest, where fisheries and the fur trade had become objects of material importance to England, Vancouver was directed to make an accurate survey of the coast from the thirtieth parallel northwestward to Cook's River, "to pay particular attention to the examination of the supposed Strait of Fuca, said to be situated between 48° and 49° north latitude, and to lead through an opening which the sloop Washington was reported to have passed in 1789." He was further directed to enter and explore all the waters, rivers, and inlets of that coast only so far as they were navigable for sea-going vessels, and on no account whatever to touch at any port of the northwest coast south of the thirtieth parallel of latitude.

Vancouver, though amply provided with means and instruments, was not so well provided as Cook and La Pérouse had been with scientific observers. Hence the task of making astronomical and nautical observations devolved on Vancouver personally. He had "amongst the officers and young gentlemen of his quarter deck a few who, with a little instruction, would soon be enabled to construct charts, take plans of bays and harbors, draw landscapes, and make faithful portraits of the headlands, coasts, and countries which might be discovered." His able officers deserve to be mentioned, as their names are attached to inlets, bays, and capes to this day. Those in the ship Discovery were Zacharia Mudge, Peter Puget, Joseph Baker, and Joseph Whidbey. The Chatham was commanded by Lieut. W. R. Broughton, and the officers associated with him were James Hanson and James Johnstone.

Vancouver, like most of his predecessors, made the Sandwich Islands his chief place of resort and his winter station. He sailed from England on the 1st of April, 1791, and arrived at the Sandwich Islands on the 1st of March, 1792. On the 18th of the same month he again went to sea, and saw the coast of New Albion, and also Cape Mendocino, and from thence sailed northward, as far as the Strait of Fuca, with favorable winds. He kept the coast in view, as the weather was clear, at an average distance of about 3 leagues from land. "When the weather prevented our making free with the shore or our hauling off for the night, the return of fine weather and the daylight uniformly brought us, if not to the identical spot we had departed from, at least within a few miles of it, and never beyond the northern limits of the coast which we had previously seen. This afforded the most complete opportunity of determining its various turnings and windings, as also the position of all its conspicuous points, ascertained by meridional altitudes for the latitude, and observations by the chronometer, which we had the good fortune to record once, and in general twice, every day." He noted accurately the configuration and soundings near Cape Mendocino, and explored the sandy beach near Humboldt Bay, but did not enter that body of water. He also recognized and named the capes Rocky Point, Point Saint George, Cape Orford, Cape Gregory, Cape Perpetua, and Cape Foulweather, where Captain Cook had touched the coast; likewise Cape Disappointment and Deception Bay, names given by Meares to the entrance of Heceta Inlet, now Columbia River entrance. There Vancouver was deceived as Meares had been. He saw breakers, and "not considering this opening worthy of more attention," he passed on with pleasant weather and a favoring breeze which he was anxious to improve. He endeavored to enter Shoalwater Bay but was unable, and did not attempt to get a nearer view of the country, being attracted when off Gray's Harbor by a high cape in the distance, named by him Cape Grenville. He recognized the Island of Destruction, named by Captain Berkeley, and "approached with increasing curiosity and excitement the region where De Fuca's strait was said to be."

On the 29th of April Vancouver fell in with the American ship Columbia, commanded by

Capt. Robert Gray, the same officer who in the sloop Washington was said to have sailed through De Fuca's strait to an interior sea. With him Vancouver conferred and learned that Gray had seen only about 50 miles of the strait; but Gray gave more important information in regard to the mouth of a large river which he had seen in latitude 46° 10′. Vancouver kept on northward, looking for the promontory named by Captain Cook Cape Flattery, but because of discrepancy in the latitude he could not identify the place with complete satisfaction. He concluded, however, that the northwestern end of the land 2 miles from Tatooche Island, which he had called Cape Classet, must be the point so named by Cook, and therefore adopted the name on his chart. He accounted for the discrepancy in latitude by supposing that Cook had been carried by the currents farther north than he was aware of, but in that conclusion Vancouver probably erred. The headland which Cook called Cape Flattery was not the same as that named by Meares and Vancouver Cape Classet, but was more probably the Flattery Rocks.

A rock standing northwest from the Cape, Vancouver named Rock Duncan, in compliment to an English captain from whom he received an excellent sketch of the entrance of the Strait of Fuca. The sketch is doubtless the same "sketch of the coast of North America from Nootka down to 47 degrees north latitude, including the Gulf of Juan de Fuca," of which mention is made by the Lords of the Admiralty in their additional instructions to Vancouver. Dalrymple in the year 1791 published Captain Duncan's chart of the Strait. On the evening of the 29th of April Vancouver entered it, sailed next day along the south shore, and gave the name New Dungeness to a low sandy point which resembled Dungeness in the British Channel. In the course of the following day he examined and named Port Discovery without knowing that two years earlier it had been named by the Spaniards Puerto de Quadra. There he moored his vessels for repair, left a party on shore in charge of Mr. Broughton, and then with boats went eastward to explore the unknown waters. The party under Vancouver started on the 7th of May with provisions for five days. After rounding the eastern entrance of Port Discovery they entered a broad inlet, with two branches stretching south-southwest and south-southeast. In the western arm a harbor was found similar to Port Discovery, and to it was given the name Port Townshend, in compliment to the English marquis of that title. A high, steep cliff forming the point which divides the harbor from the broad eastern inlet was called Marrowstone Point, because it seemed to be composed of a species of marrowstone.

On the 9th of May Vancouver went southward into Admiralty Sound, and saw on the western shore a small bay fringed by large trees. This he named Oak Cove. From a high perpendicular bluff, marked by him as Foulweather Bluff, he observed that the inlet separated, as at Marrowstone Point, into two branches. The western arm was explored as far as Hazel Point, a name which he applied because of the abundance of those trees; but it has since been known as New Kolowan Point. From thence the channel sends out a short arm or bay to the north, and this was explored by Vancouver, but was not named.

He then passed into the southwestern extremity of the great canal, and according to his observations it ended in latitude 47° 21′ north. Hoping that some communication with the east might be found in Admiralty Inlet, Lieutenant Johntone was sent to examine that quarter, but, according to his report, the arm known as Hood's Canal was overlooked. This was subsequently examined and traced by the exploring expedition, under Captain Wilkes. Vancouver, however, passed through it and named it for one of the Lords of the Admiralty. He resolved to explore the broad inlet (Admiralty Inlet) with the ship Discovery, while Mr. Broughton, in the Chatham, was examining the islands northeast of the Strait of Fuca.

On the 18th of May both vessels moved accordingly, and Vancouver entered the main body of Admiralty Inlet. He found an attractive region. A point of land near a good roadstead he first named Village Point, from an Indian village in that vicinity, but afterwards he marked it as Restoration Point, having, as he says, "celebrated that memorable event when at anchor under it." This point, lying at the northern entrance of Port Orchard, north of a small island now known as Blake Island, he made the principal station while exploring the sound. From thence he sent out parties to examine the different water branches, and there he awaited the return of the party in the Chatham. Towards the south, Admiralty Inlet shows two branches, separated by Vashon Island. To explore the southwestern arm a party was sent in boats under Lieutenant Puget, on the 19th of May. Meanwhile Vancouver and his men examined the vicinity, and approaches to

their station. A narrow inlet seems to form a small cove, but when explored by Mr. Orchard it was found to communicate with other waters. A boat expedition found it to be an interior basin with several branches, and it was named Port Orchard. On Vancouver's chart it is shown as a closed basin, but subsequently his sketch was corrected when it became known that this so-called port had other branches, communications, and passages.

On the 25th of May Mr. Broughton returned to the Chatham from his northern excursion, and joining Vancouver off Port Orchard gave him intelligence of a large assemblage of islands northeast of the Strait of Fuca: the Haro Archipelago. Vancouver set out on the following day to explore further south the main arm of the great channel (Admiralty Inlet), at the same time directing that, on the return of Puget and his party, Broughton was to examine a branch to the northeast, the entrance of which had been seen on the eastern shore. Vancouver had noticed on that shore, in latitude 47° 17′ north, an opening which he supposed might lead far to the eastward, as a range of distant snow-clad mountains was marked by a break corresponding with the direction of the branch. He soon after found there only the closed body of water now known as Commencement Bay. Proceeding on the main water, another land opening was seen leading in the direction to the place at which the ships were moored. The land proved to be a large island. He sailed around it and named it Vashon Island, in memory of his friend, Captain Vashon, of the British navy. Keeping on south and west various bays and branches were explored, but they all ended in swampy ground. On Monday the 28th he reached the south end of Admiralty Inlet, and on his chart placed it in latitude 47° 03′ north, and longitude 237° 18′ west. To the east and south all was inclosed by land and he had already entered the quarter which had been assigned to Mr. Puget. He therefore returned and reached the anchorage on the 29th of May, on his way passing the western side of Vashon Island. Puget had passed quite through the southwestern part of Admiralty Inlet, and to that branch Vancouver gave the name of Puget Sound.

Broughton had sailed to the branch which was afterwards called Possession Sound, and there the returning party found the Chatham at anchor on the 30th of May.

Mr. Whidbey had been previously sent in a boat to explore the northern branches of that sound. One was named Port Susan, but it is now known that it has an opening to the north. Another was named Port Gardner, and to a small harbor found by the party Vancouver gave the name of Penn's Cove.

The officers and men of Vancouver's company being again collected, and, as he judged, the exploration being complete, the commander concluded to take formal possession of the region before proceeding to another field of research. That ceremony was performed on the 4th of June, the anniversary of the birth of King George III. Vancouver went ashore, and with customary formalities claimed all the coasts from that part of New Albion in latitude 39° 20′ north to the entrance of the Strait of Fuca; also the islands within the strait, those in the interior sea, and all the channels and branches of that sea. To these collectively he gave the name Gulf of Georgia. The adjacent tract he called New Georgia, and the bay or inlet where the ceremonies were performed was named Possession Sound.

On the 6th of June both ships sailed through the entrance of Admiralty Inlet to the north around the cape to which was then given the name Point Partridge, and, when near what is now called Smith's Island, Whidbey was sent with boats to explore two entrances visible on the main shore towards the northeast, the vessels keeping on north to a harbor seen by Broughton when he was cruising with the Chatham at the end of May. He had named the place Strawberry Bay. This port was on the southeastern side of an island, called by Vancouver Cypress Island, where the ships were moored to await the return of the boats. There Whidbey arrived on the 10th of June, and reported that having entered the most southern of the two inlets he found it a narrow and intricate channel abounding in rocks and communicating with another previously discovered by him, which was supposed to be closed, and was named Port Gardner. The name given to the one last visited was Deception Passage, and the long strip of land which Whidbey had proved to be an island was named after him, Whidbey Island. After leaving Deception Passage he had entered an inlet to the northeast and found an extensive bay, the shore lines of which he did not trace. They left Strawberry Bay, and going north anchored on the 11th June in another, which was afterwards called Birch Bay, where Vancouver intended to establish a central station for

further operations and boat excursions. There Broughton was left in command, and was directed to make astronomical observations, while Whidbey went southeast to complete the survey of the great bay he had discovered from Deception Passage; and Vancouver in person started with boats to the north to examine the shore of the continent. He left Birch Bay on the 12th of June, and explored two bays, but assigned no name to either. Passing around a long, low peninsula, west of these, he called it Point Roberts, after Capt. Henry Roberts, his predecessor in the command of the ship Discovery, and sailed along the shores of the delta of what is now known as Frazer's River. Here the soundings diminished from 10 fathoms to 1 fathom, and all endeavors to approach the eastern shore were to no purpose. The sand bank was so extensive that in order to clear it he was constrained to pass westward to anchor for the night. Next day he again started in a northeast direction and found a cape which he named Point Gray, in compliment to Capt. George Gray. The space between this and Point Roberts seemed to be "a low flat very much inundated, and to have two openings between the two points." These were doubtless the mouths of Frazer's River. The sand bank between them he named Sturgeon Bank, as he had bought some sturgeon there from Indian fishermen. Thus Vancouver missed the discovery of the largest river in New Georgia, as he had previously overlooked the Columbia River entrance.

From Point Gray he surveyed three extensive channels, named by him Buzzard's Canal, Howe's Sound, and Jervis Canal. On his way southward Vancouver met on the 22d of June two Spanish vessels near Gray's Point; and in conversation with Captains Valdez and Galianos learned that the expedition under Elisa had in the preceding year, and earlier than himself, examined the shores of the Gulf of Georgia. They exhibited Elisa's charts, and Vancouver saw on them the shore lines of bays and other geographical details extending 4 leagues further than he had advanced. The Spanish commanders were surprised when told that Vancouver had not seen the river entrance which Elisa had named Rio Blanco. The English commander evidently knew nothing of the existence of Frazer's River.

On the 23d of June Vancouver again was at the anchorage of his vessels in Birch Bay. Whidbey had previously arrived from his boat excursion to the eastward, and reported that he had examined a large expanse of water; and on his chart Vancouver marked it with the name Bellingham Bay. Other boats had been employed in the examination of islands at the west, but "these were found so abundantly dispersed as to preclude any correct examination without having leisure for the purpose." Thus, having traced only the southern and eastern parts, the development of the Haro Archipelago was left to later explorers. With a fine breeze and very pleasant weather, the two ships sailed from Birch Bay on midsummer morning and proceeded northwestward up the gulf. Soon after, Vancouver again met the Spanish expedition under Valdez and Galiano, and the three commanders resolved to carry on the work of discovery jointly. Sometimes the exploration of an inlet or cape was confided to the Spanish, and at other times to the English officers; but the partnership was soon dissolved. After the 13th of July each party pursued its own course.

Vancouver sent Lieutenant Johnstone in a boat to ascertain whether or not the inland waters on which they now were had any outlet to the Pacific. After passing through narrow straits, it was found that the tide entered from the northwest; and as the party advanced many Indian canoes were met, and as generally near the mouth of an outlet the shores were studded with Indian settlements he judged that he was in a passage to some other water, and soon after saw a broad sheet of ocean in the distance. On the chart the passage was marked Johnstone Strait. On the 10th of August Vancouver entered the Pacific and passed along the coast to the 52d parallel, returned around the island, and arrived at Nootka on the 27th of the same month. Four days after he was followed by the Spanish ships Sutil and Mexicana, which had also explored Johnstone's Strait with its numerous branches and inlets, and had given names to all. Vancouver preceded them, and it is proper that geographical names attached by that navigator should be retained on existing charts. With Quadra, the Spanish governor, then resident at Nootka, Vancouver agreed, and the great island was named Quadra and Vancouver Island. In October of the same year (1792) he sailed for the Sandwich Islands, which had become, since the time of Captain Cook and the fur-traders, a harbor of resort for the northwestern navigators from England and Eastern America. Vancouver left Nootka with three vessels, the Discovery, the Chatham, and the Dædalus. After remaining a short time in sight of the southern coast of the island, he crossed the approaches

of the Strait of Fuca. Captain Cook had applied the name Cape Flattery to what Vancouver had called Cape Classet, but, on finding that his designation was the name of an inferior Indian chief, Vancouver adopted the name which the cape now bears.

On the 18th of October he was off Bulfinch Harbor, so called by Captain Gray, who discovered it, and from thence Mr. Whidbey was sent in the Daedalus to explore the port. Vancouver in the Discovery, and Broughton in the Chatham, went on to the entrance of Columbia River, and there the Chatham was directed to lead in, and signal at the bar if not more than 4 fathoms of water should be found on it. She safely made her way in, but the Discovery in following soon came into 3 fathoms. Vancouver considered his vessel in danger, and hauled to the westward. The day following he made two other attempts to enter and reach the Chatham. The weather was clear and favorable. Vancouver saw far into the valley, and observed to the eastward a high snow-clad mountain, which he named Mount Saint Helens, in honor of the British ambassador at Madrid. It is a peak of the great range of mountains south of Mount Baker and Mount Rainier. On the 21st, as the weather looked threatening, Vancouver stood out to sea, leaving the exploration of the river entrance to his lieutenant, Broughton. On the way southward the commander again determined the geographical position of Cape Mendocino, and found the latitude to correspond exactly with his former observation. The longitude determination was within 3′, and this proved the accuracy of his first survey. From thence he made a quick passage to San Francisco Bay, where he arrived on the 14th of November, and was rejoined in the following week by Mr. Broughton, who had returned in the Chatham after exploring the Columbia River. He safely passed the bar of that river and anchored about a mile and a quarter inside of it. Seeing the Discovery put to sea again Broughton supposed he was left to examine further. He had no definite instructions, but went on eastward, guided at the outset by a sketch made by the American, Captain Gray. Broughton sounded in different directions, and gave names to several points and bays. Young's Bay and Young's River he named after Sir George Young, of the Royal Navy; Gray's Bay he named in compliment to the American captain, and Baker's Bay for the commander of a small vessel, the Jenney, which had entered the Columbia before the Chatham. In the course of ten days Broughton went about 80 miles up the river, and gave names to several points, islands, and branches. It is now difficult to identify the places, as the sketch published by Vancouver (plate 5 of his atlas) contains only a few of the names. But this is not important. It suffices to state that he went up the river nearly to the great mountain range, and only a few leagues west from the Cascades, which were described to him by an Indian. He named the place at which he turned back Point Vancouver. Possibly the river Mannings, of Broughton, may be the Willamette, but the latitudes do not agree closely.

On the 4th of November Mr. Broughton was again on board the Chatham. He put to sea on the 10th, and ten days afterwards rejoined Vancouver at San Francisco.

While his vessel was at anchor at the entrance of Gray's Harbor, Whidbey had examined the bar in boats, and finding a channel of 18 feet he passed in and moored off the north point of the entrance. From that place he began his exploration in boats and completed it on the 26th. The north point of entrance he named Point Brown, in honor of Captain, afterwards Admiral Brown, of the British navy. The southern was named Point Hanson, for the lieutenant who had commanded the Daedalus in the passage from England. To a point inside of the bay 4 miles east of Point Brown he gave the name Point New, after the master of his vessel. Mr. Whidbey left probably on the 27th of October, and rejoined his commander at Monterey about the middle of November. Vancouver remained at San Francisco Bay only to make a sketch of the entrance, and some visits to the neighboring missions. He left on the 25th of November, and "delineating the coast," proceeded to Monterey, where he arrived on the 26th and remained until the end of the year 1792, occupied in exploring the vicinity and preparing charts, drawings, reports, and letters for England. He determined the longitude of his observatory, near the Presidio of Monterey, from a series of nearly two hundred sets of observations, to be 238° 25′ 45″ east. "This result" Vancouver remarks, "differs considerably from that of Malaspina, who places Monterey 35 miles farther to the west, in 237° 51′, and he also places the northern promontory of Cape Mendocino 26′, and Point de los Reyes 33′ farther to the westward of their positions as shown by our observations.' By Vancouver's calculations the entire coast of North America was uniformly moved about 30

miles eastward of the longitude assigned by Cook and Malaspina. "These" says Vancouver, "are authorities which demand the greatest respect and confidence, yet from the uninterrupted serenity of the weather that prevailed at the time our observations were made, I have been induced to adopt the meridian obtained from the result of our own observations."

On the 14th of January, 1793, Vancouver left Monterey and sailed directly for the Sandwich Islands, where he remained until the end of March, and then set out on a second voyage. He made the coast near Cape Mendocino, and having on his first visit in 1792 passed Port Trinidad unnoticed, which, according to the Admiralty Register of 1781, "appeared to be an eligible place for shipping," he entered it on the 2d of May, and anchored in "a small open cove, bounded by detached rocks." "When moored," he says, "the bearings from the ships were a high, steep, rounding, rocky headland, (Trinidad Head) forming the bay, bearing N. 75° W., distant three quarters of a mile, and the distant headland of Mendocino in sight towards the south." This description proves that the vessel was in the little cove on the shore of which now stands the town of Trinidad. All hidden dangers there have been developed in the work of the Coast Survey, but Vancouver reported it to be "a very unsafe roadstead for shipping, scarcely deserving the denomination of a port." In an excursion to the shore one of his officers found the cross which had been erected by the Spaniards under Quadra y Bodega in 1775, bearing the inscription "Carolus III Dei G. Hyspaniarum Rex." On the 5th of May he again stood out to sea and sailed for Nootka.

Between the islands of Vancouver and Queen Charlotte's there is a large gulf. The last named island stretches some of its promontories far to the west and advances more into the ocean than other islands of that region. Hence it was one of the first chosen for exploration. Towards the east and nearer to the mainland lies a labyrinth of islands, inlets, channels, and long peninsulas, which, up to the time now under review, had been considered as part of the continent. Vancouver entered these waters, and in this was preceded only by one navigator, the Spanish captain, Coamaño, whose observations were useful to the English navigator. The Spaniard, of whose voyage further mention will be made presently, sailed from Mexico when the Sutil and Mexicana started, and in the course of six months surveyed many parts of the archipelagos of Revillagigedo, Prince of Wales Island, &c. Some of the names given by him were retained by Vancouver, which proves that he must have known something of Coamaño's results and was materially assisted by his charts, which, in the opinion of Humboldt, he probably had on board. But much the greatest degree of merit regarding these explorations must be accorded to Vancouver. Here in the north, as formerly in the south, near the Gulf of Georgia and at the mouth of Columbia River, Vancouver and his officers, by advancing through the deeply indented inlets, approached those remarkable mountains that run along the northwest coast of America. A few high summits of the coast ranges and some isolated peaks were previously known, as, for example, Mount Saint Elias, Mount Fairweather, Mount Edgecumbe, and others; but the interior ranges had never been seen by Europeans. Vancouver traced them from California northward to Russian America.

On the 8th of October Vancouver left Nootka, and in the course of a week he was off Cape Mendocino. Lieutenant Puget was sent to gain information concerning Port Bodega, but as in the year previous, inclement weather made the intended survey impracticable. Vancouver meanwhile went to San Francisco, but the Spanish authorities were not cordial, and he kept on to Monterey. On the 5th of November he sailed again to complete his examination of the coast southward to the 30th parallel, as enjoined by his instructions. He passed along to Point Conception and from thence through the Santa Barbara Channel to San Diego. Favored by circumstances he everywhere approached the shore line, entered little harbors, and gave names to several points which he found to be nameless on the Spanish maps, as Point Sal, Point Arguello, Point Felipe, Point Firmin, Point Vincente, Point Lasuen, Point Dume, which have been adopted by geographers, and Vancouver has thus commemorated many noble and hospitable Spanish friends, both officers and missionaries, Don Sal, Don Arguello, Don Felipe Goyeochea, Father Francisco Dume, Father Vincente, and Father Lasuen, each of whom had received him cordially as he stopped at intervals in passing along the coast. He left San Diego on the 9th of December and coasted as far as San Francisco entrance. From thence he stood over to the Island of Guadalupe and the Sandwich Islands, intending to make his winter station there for the season of 1793–'94.

Among the non-existing waters marked on maps, even after the time of Captain Cook, was that deep and large inlet in Russian America, called Cook's River. It had been mistaken for the mouth of a great stream like the Saint Lawrence. Some in that day eagerly caught at the idea, and with no knowledge of mountain systems they gave the river a source in the Great Slave Lake. Mackenzie, it is true, showed that the waters of the Slave Lake flowed towards the Arctic Ocean, but space remained west of Mackenzie's River for the mythical stream once known as Cook's River.

On his third northwestern cruise, in the summer of 1794, Vancouver closely examined the surrounding country and expunged imaginary rivers which had been marked on earlier maps. To the one last mentioned after examination he gave the name Cook's Inlet, its proper designation. But he omitted some that were important. In the north, as twice before at the south, he was thus unfortunate. He had doubted the existence of the Columbia River until Gray proved it, and he left Frazer's River in the Gulf of Georgia unexplored, although informed of its character by intelligent Spanish officers. Of the Atna or Copper River of the Russians he says nothing, nor did he hear anything of the large river Yukon or Yukehanna.

Vancouver returned to Nootka, and passing along the coast of California he again made some observations of importance; but he was anxious to visit San Diego. That station being central, all his calculations for determining the trend of the coast of New Albion southward of the thirtieth parallel were referred to it. On the way he touched at two points for connecting and correcting his series of longitude determinations, at the island of Guadalupe, the position of which he had previously ascertained, and at Cape San Lucas. There the French expedition under Chappe d'Auteroche for observing the Transit of Venus in 1769 had settled the geographical position with a high degree of exactness; and finding by comparison his results in accordance with those of the Spanish and French observers, Vancouver returned to Europe. He reached England in the summer of 1795.

Cook, La Pérouse, and Malaspina had touched the western coast here and there, but Vancouver was the first in attempting a continuous survey. The Spanish voyages of that period, even when intended to aid in geographical development, were commonly mere summer excursions; but Vancouver took ample time. His explorations employed three summers from the date of his arrival at the northwest in April, 1792, until his departure in September, 1794. Moreover, many of the previous expeditions had been conducted by men of merely ordinary acquirements, captains of merchant vessels and fur traders, like Portlock, Dixon, Marchand, Gray, and others, who of course occasionally made discoveries in a region so little known. Vancouver and his companions possessed the qualities and the means requisite for his purposes. He had been trained under Captain Cook, and was provided with the best instruments then known for making useful observations. The period of his survey was probably the most active in the history of western exploration. He states that in 1792 there were upwards of twenty fur-trading vessels on the coast, and exclusive of his own three ships, the Spaniards had two under Valdez and Galiano; two or three men of war under Bodega y Quadra, sent to Nootka Sound; and the surveying vessel Aranzas, under Captain Caemaño. The total of thirty vessels were conducted by officers of ability, and were accompanied by astronomers. All contributed to make those hitherto obscure regions better known. No former time had gathered such means and forces for coast exploration.

After the disclosures made by Cook in 1786 had directed attention to the Northern Pacific, citizens of the United States, as also some in England, France, and other countries, sent expeditions to that promising region to engage in the fur trade; and some Americans while so employed became as prominent in the history of discovery as Marchand, Meares, and Dixon, of whom mention has been made. Amongst them, the Captains Kendrick, Gray, and Ingraham are best known. But few of the American captains wrote narratives of their voyages. All probably kept log books or journals, but these were not published, and probably have been lost. Of Capt. John Kendrick's papers none, so far as we know, have been published or even preserved. The log book of Capt. Robert Gray was for some time in possession of his heirs, and from the second volume a few extracts were published in Boston, but nothing is now known of the manuscript. The journal of Capt. Joseph Ingraham's voyage in the ship Hope, in manuscript, is in the library of the State Department in Washington City, D. C. It is in four thin folio volumes, very well written, and contains maps of Washington Island, as he calls Queen Charlotte's; also of Vancouver Island,

and of the coast of California, drawn from information given by Captain Gray. Much information in regard to the explorations of the earliest American navigators in this direction is given here and there in the reports of Dixon, Meares, Vancouver, and others.

In the year 1787 some Boston merchants, among whom were Mr. C. Bulfinch and Mr. J. M. Pintard, formed an association for combining the fur trade of the North Pacific with the China trade, in a manner similar to that attempted by the King George's Sound Company of London. They fitted out two vessels the Columbia, and the Washington, with requisites, and gave the direction of the expedition to Captain Kendrick, with whom, in the Columbia, Ingraham went as mate, Gray had command of the Washington, and both were provided with sea letters issued by the Federal Government, and the vessels sailed from Boston on the 30th of September, 1787. Greenhow, in his work on Oregon and California, gives ample information in regard to the voyages of Kendrick, Gray and Ingraham.

In January, 1788, they doubled Cape Horn and immediately afterwards the vessels were separated by a violent storm; Captain Gray, in the Washington, made the northwest coast in latitude 46 degrees north, and reached an inlet or coast opening which he tried but in vain to enter. This was probably the mouth of Columbia River. On the bar his vessel grounded, and was attacked by the natives; but he got off without much injury, and on the 17th of September he arrived at Nootka Sound, the place of rendezvous, where he was soon followed by Captain Kendrick in the Columbia. Occupied with transactions in the fur trade, the vessels remained in harbor during the winter of 1788–'89. The Columbia passed the following summer there, but the Washington made trips to the north and south, exploring the country, and collecting furs, which Gray from time to time deposited at Nootka. In one of his trading excursions (June, 1789) he explored the eastern coast of Queen Charlotte's Island. The western shore had been seen by the Spaniard Perez, in 1774, by the French under La Pérouse in 1786, and by the English, Captain Dixon, in 1787, who had also observed partially along the east side and discovered the broad strait which separates it from the continent. He called the island Queen Charlotte's, and the channel Dixon's Strait.

Not knowing the facts which have just been stated, Captain Gray believed himself to be the discoverer of the great island, the eastern coast of which he saw and followed further than either of his predecessors. He touched also at many points along the shore, and gave it the name of Washington Island, and that designation was in use for some years among the fur traders of the United States.

In one of his voyages from Nootka to the south, Gray entered the strait discovered by Captain Berkeley in 1787, and by him named De Fuca Strait. Gray sailed in it about 50 miles, and understood from the natives that it extended farther north, and then returned towards the Pacific. Gray afterwards related this to Vancouver, but he nowhere states why he did not pursue this promising opening. On his return to Nootka he found Captain Kendrick preparing to sail with furs for China, but after hearing the account given by Gray respecting the Strait of Fuca it was decided that the latter should take the Columbia across to China, while Kendrick remained with the Washington on the northwest coast.

Gray arrived at Canton on the 6th of December, 1789, sold his furs, and returning with a cargo of tea by way of the Cape of Good Hope, reached Boston on the 10th of August, 1790, having carried the flag of United States around the world. What Captain Kendrick did meanwhile is not exactly known. Mr. Greenhow says that on parting with the Columbia he sailed in the Washington to the Strait of Fuca, and was the first navigator who passed through its entire length into the Gulf of Georgia. We will therefore briefly recapitulate what is known certainly in regard to Kendrick's movements, voyages, and fate, after his separation from Gray in the autumn of 1789.

We know that after the separation he engaged in speculations, one of which was the collection of the odoriferous sandal-wood which grows on many islands of the Pacific, and that he took the wood to China. He purchased several tracts of land near Nootka from the Indian chief Maguinna, and he was again at Nootka in the summer of 1791. In that same summer Captain Gray returned to Vancouver Island and passed the following winter at Clyoquot Sound. It is probable that he went once or twice to Nootka and there saw and conferred with his former commander. At the

end of the year 1791 Kendrick probably sailed for China, as early in the ensuing year he was seen there by Captain Ingraham, of the American ship Hope, who had been at Macao since the 1st of December. Ingraham had previously sailed with Kendrick as mate, and of course had some conversation with him, as explicitly stated in his journal. Kendrick was killed by an accident at the Sandwich Islands in the year 1793. So far as we know he made no important discoveries, but his countryman, Robert Gray, made several. The anonymous author of three letters from California called "Noticias de la Provincia de Californias" (not to be confounded with the noticias of Venegas) says that the viceroy of Spain had sent out letters to all the missions, directing that notice should be given to the Indians of a certain American-Englishman named Juan Kendrig, sailing about their coast, who had coined and issued money in his own name, and ordering them to seize him wherever they could.

The results of Gray's commercial operations were not large, but he sailed again in the ship Columbia from Boston on the 28th of September, 1790. Several other vessels sailed at about the same time from that port and from New York, bound for the North Pacific, and amongst them was the brig Hope, commanded by Joseph Ingraham, formerly mate of the Columbia.

On his second northwestern voyage Gray arrived at Clyaquot (Vancouver Island) on the 5th of June, 1791, as stated by Greenhow. From thence he went to higher latitudes and returned in the autumn to Clyaquot, where he built a fort (Fort Defiance) and passed the winter of 1791-'92. In the following spring he made a trip southward along the coast of New Albion. At the outset, on the 29th of April, 1792, he met Vancouver and conversed with him respecting the Strait of Fuca and a certain great river (Columbia River), to which allusion has already been made.

After parting with Vancouver Gray went southward. On the 7th of May he discovered in latitude 46° 58′ north an inlet which seemed to promise a good harbor. He entered and found himself in a bay "well sheltered from the sea by long sand-bars and spits." There he remained three days, trading with the natives, and named the place Bulfinch Harbor, in honor of one of the owners of his vessel. This same bay was afterwards called Gray's Harbor by Vancouver.

On the 11th of May Gray was again near the entrance seen by him in 1788, which in his log-book is styled his "desired port," probably because he had great expectations in regard to it. On passing the bar he found the entrance of a large river of fresh water, and remained ten days trading with Indians. According to his log-book the exploration then made was prosecuted to a point nearly 25 miles by the river course. When Gray left he gave to the river the name Columbia River, after his ship. The entrance cape he called Capes Hancock and Point Adams. Soon afterwards he made known at Nootka Sound the discovery of Bulfinch Harbor and Columbia River to the Spanish commander Quadra, and subsequently to Vancouver, who ordered a further exploration of the vicinity.

From Nootka Sound Gray returned, by the way of China, to the United States.

Captain Ingraham, in the ship Hope, left Boston in September, 1790. While crossing the Pacific he touched at a group of unknown islands, and then went northward to Queen Charlotte's. He made a second voyage to that island in 1792. The journal of his voyages is important, as it preserves notices of other American explorers, chiefly of Kendrick and Gray; and from the last named communicates a map of Vancouver Island and the coast of California. In 1793 Ingraham returned, by way of China, to the United States. Subsequently he was an officer on board the ill-fated ship Pickering, which was never heard of after sailing from the Delaware in August 1800.

GALIANO AND VALDEZ, 1792.

An account of the voyage made with the galiots Sutil and Mexicana was published at Madrid in the year 1802. The introduction to the narrative was written by the Spanish historiographer and director of the archives, Navarrete, but the name of the author of the account is not mentioned. The atlas which accompanies it contains charts, plans, and views; and of these the most interesting in this connection are the first plate, showing the coast of California from Cape Perpetua to Cape San Lucas; the second, on which is given the remainder of the coast of California and Vancouver Island; the fourth contains a reduced copy of the old survey of the coast of Calfornia by Vizcaino in 1602; and the fifth and sixth give plans of the harbors of San Diego and Monterey.

The most valuable part of this work is the introduction. Compared with Vancouver's the narrative is meager and uninteresting and the charts are inferior, only that of Vizcaino having any special historical interest. They are not equal to the Spanish charts given in the Madrid atlas of that period.

Malaspina was on the northwest coast in the year 1791, but had not time to examine the Strait of Fuca. After his return to Mexico he submitted to the viceroy a plan for the examination of certain important places, and offered to furnish the expedition with instruments from his vessels. This proposition was accepted. The galiots Sutil and Mexicana were fitted out, and placed under the command of the captains Don Dionisio Alcada Galiano and Don Cayelano Valdez. It was the last of Spanish expeditions. The equipment was meager. The vessels were each only about 50 feet long, of less than 50 tons burden, and were navigated by only twenty-four men. Each ship had one chronometer, and a single quadrant did service for both of the vessels. Vancouver was amazed at the sight of what he deemed "so unfit for its destination." Both Valdez and Galiano complained of the inconvenience of such small vessels. They sailed from Acapulco on the 8th of March, 1792, traversed the coast of California at a distance, to avoid the northwest winds, and arrived at Nootka on the 12th of May. From thence they sailed on the 3d of June, and on the 5th entered the Strait of Fuca. Tetacuo, an Indian chief, informed them that Vancouver had been there five weeks earlier, with two large ships.

After visiting the little port of Nuñez Gaona (Neah Harbor), the Spaniards passed to the eastern part of the strait without examining Port Discovery or any other harbor of that vicinity, "because their predecessor Elisa had already seen them." They also passed by Las Bocas de Caomaño (Admiralty Inlet), partly for such reasons as had induced Elisa to leave it unexplored and partly because it was thought that the inlet might lead in a southwestern direction to the inlet of Heceta (mouth of Columbia River), and if so, it could be more conveniently examined on their return.

Hastening therefore to Rosario Strait, to reach as soon as possible the point at which Elisa closed the survey, they sailed for the southern point of Vancouver Island, and having doubled it, kept along the southern shores of the archipelago De Haro, passed the island of Guemes, and entered the Seno de Gaston (Bellingham Bay), to see if there was not a channel leading from it to the north. Finding no outlet they made their way to what Elisa in 1791, had called Canal de Florida Blanca, in hope that it might lead to something yet undiscovered. Elisa had mentioned the existence of a river in that region, which river, according to Vancouver, he called Rio Blancho. There they of necessity repeated Vancouver's movements. Finding turbid water (aguas turbias) and very shallow soundings, they were driven by currents, and went over to the eastern side of Vancouver Island to seek for an anchorage. There they passed several days in different roadsteads to which they gave names, after marking shore lines on the chart.

Elisa had represented the country about the mouth of Fraser River as composed of islands. The ridge of snow-clad mountains to the eastward seemed to be broken in the direction taken by the Canal de Florida Blanca, showing a broad valley; and it was judged that the canal there passed the mountains and led into another sea. But Fraser River was not examined, either by Vancouver, Valdez, or Galiano. In the previous year Elisa appears to have seen something of it, as on his map it is laid down as a river. While Galiano and Valdez were near its mouth, they met the boats of Vancouver and conversed with his officers. The two parties at length joined, and completed the survey of the Gulf of Georgia. The Spanish report states that the Spaniards did the best they could to follow their English friends, but always were somewhat behind in consequence of the inferiority of the Spanish vessels. They entered the Pacific through the strait named on their chart Salida de las Goletas. This is south of the island marked on Vancouver's chart as Island of Galiano and Valdez. On the 27th of August they sailed around Vancouver Island, and on the 31st arrived at Nootka. On the 10th of August Vancouver entered the Pacific, and after making some explorations at the north of the island, reached Nootka on the 28th of the same month. The English certainly preceded in navigating entirely around the island; but it was agreed between the commanders that it should bear the name Quadra and Vancouver Island.

On the 1st day of September Galiano and Valdez left Nootka to cruise along the coast of California towards Monterey, and to survey places pointed out by their instructions. Like Van-

couver, they heard at Nootka of a newly discovered port (Gray's Harbor), and of a large river mouth (Columbia River), discovered by the American Captain Gray. The intention was to examine both, but owing to the bad condition of their vessels the purpose was found impracticable. With their small craft and unfavorable wind and weather they made their way south, touched at San Francisco, Monterey, and San Diego, and arrived at San Blas on the 23d of November. Humboldt mentions these Spanish officers as "able and experienced astronomers"; but they recorded no observation or discovery worthy of mention.

In the Strait of Fuca the commanders Galiano and Valdez had been preceded by Quimper, Elisa, and Vancouver, and in the Gulf of Georgia they were assisted by the English. Spanish charts with early designations were published in 1802, but Vancouver's charts, much superior in detail, came out in 1798, and thus were established the names which he had attached to places in the region.

CAAMAÑO, 1792.

Brief mention will suffice of an expedition by Don Jacinto Caamaño in the Spanish ship Aranzazu. This voyage, like that of the Sutil and Mexicana, was ordered by the Viceroy of Mexico, Count Revillagigedo, and was suggested by Malaspina, who judged that somewhere about Port Bucareli, in latitude 56 degrees north, and behind Queen Charlotte's Island might be found the open water of Admiral Fonte.

Caamaño left San Blas on the 20th of March, a fortnight later than Galiano and Valdez. Like them he traversed the coast of California, and he arrived at Nootka on the 14th of May. From thence he went north and passed around Queen Charlotte's Island. Many observations were made on the neighboring shores of the American continent. These, as Humboldt remarks, were useful to Vancouver, but they are beyond the boundary of our present research. On his return in October, 1792, Caamaño, sailing with northwestern winds along the coast of California, touched at several points, but seems to have added nothing to the stock of information. He reached San Blas on the 4th of November, where, a fortnight after, Galiano and Valdez arrived with the Sutil and Mexicana. In these the Spanish Government ended a long series of exertions for exploring the northwest coast. Beginning with Ulloa and Cortes, a period of nearly three hundred years had been marked by activity in geographical development.

CAPT. W. R. BROUGHTON, 1795-'98.

Broughton's voyage was from its outset very unfortunate. He had been with Vancouver in the North Pacific, and, as already stated, was in command of one of the vessels (the Chatham) of Vancouver's expedition. After examining the Columbia River, Broughton went overland across Mexico by direction of Vancouver, with communications respecting transactions with the Spanish authorities at Nootka Sound. Affairs were settled amicably by the willingness of Spain to yield possession to Great Britain. The surrender had been refused during the stay of Vancouver.

At the end of the year 1793 the ship Providence was put in charge of Broughton. He was directed to proceed to the Pacific, visit Nootka, and receive possession of that port in case the restitution to Great Britain had not been previously made. He was also instructed from the Admiralty to survey the western coast of South America between Valdivia and the Strait of Magellan "upon the supposition that Captain Vancouver, who had similar orders, would not have been able to fulfil them."

After many delays Broughton sailed from England in February, 1795, before the return of Vancouver, and arrived at Nootka (from the Sandwich Islands) on the 15th of March, 1796, and found the place at which activity had been manifested for years almost deserted. An Indian village was on the site of the early Spanish settlement, and several letters, delivered by the Indian chief Maguinna, informed Broughton that the Spaniards had delivered the port to the English Lieutenant Pierce. It was also stated that Vancouver had sailed for England.

His vessel needing repairs, Broughton could not leave Nootka until the 21st of May. He then sailed, and visited Monterey, but received no attention from the Spanish officers there, and was not even allowed to set up a tent on shore for the astronomical observations needful to settle the

rates of his watches. He ascertained definitely that Vancouver had left about eighteen months before, and that his two ships had been in good condition at Monterey. Further, that he had sailed from Valparaiso to survey the lower part of the western coast of South America. Broughton, thus apparently left to his own discretion, decided to survey part of the coast of Asia, and to that end he sailed from Monterey on the 20th of June for the Sandwich Islands. His ship was wrecked, but he made some useful surveys in the region to which La Pérouse sailed from California. He returned to England in 1799.

LEWIS AND CLARKE, 1804-'06.

In January, 1803, President Jefferson sent to the Congress of the United States a confidential message recommending the examination of the interior and far western region pertaining to the republic. The suggestion was approved, and he commissioned Captains Meriwether Lewis and William Clarke to explore the Upper Missouri River and its principal branches, and then to seek and trace to its termination some river, the Columbia, the Oregon, or any other which might offer the most direct and practicable water communication across the continent for the purposes of commerce.

Soon after the cession of Louisiana to the United States the travelers named set out westward from Saint Louis, with a party of about forty men, on the 14th of May, 1804. They went up the Missouri to the mouth of Yellowstone River, and the upper heads of the last mentioned stream were explored in 1805. In July they crossed the Rocky Mountains and reached the headwaters of the Columbia. Following its course, they arrived at the falls of the river in the Cascade Mountains, and on the 2d of November came to tide-water at the point reached by Broughton, (Vancouver's lieutenant) in 1792. Five days afterwards Lewis and Clarke reached the eastern extremity of the estuary of the Columbia, and, "the fog clearing off, enjoyed for the first time the delightful prospect of the ocean." The broad Pacific was before them. On its waters they rowed in the vicinity of Gray's Harbor, which they called Shallow Bay. Cape Disappointment and the adjacent coast were examined. They rounded Tongue Point (naming it on their map Point Williams) and selected for their winter encampment a place near their river Netul, which on later maps bears the name Lewis and Clarke's River. This empties into Young's Bay. There, on the 8th of December, they commenced building a camp, which on completion was named Fort Clatsop, and after passing the winter they began their homeward journey on the 23d of March, 1806.

Throughout the winter they had much intercourse with the Indians, and made many hunting and exploring excursions to the interior and along the coast. They noted the winter climate, the rainy season of that region, the animals, and indigenous productions, many of the vegetables being unknown at the east.

Amongst Indian tribes inhabiting the shores of the Columbia River were the Clatsops, Killamucks, Chinooks, and the Cathlametes.

Of the excursions made, one of the most interesting was led by Captain Clarke. On that journey they ascended on the 8th of January, 1806, a high and rugged headland of the coast. It was named Clarke's Point of View, and is doubtless identical with Tillamook head on charts of the United States Coast Survey.

Before leaving the mouth of the Columbia Lewis and Clarke put on paper a short memorandum of their journey to the Pacific, distributed copies to the Indians, and posted a copy at Fort Clatsop. One of these papers was subsequently given by the natives to Captain Hill, an American, who in the course of the summer of 1806 was on the Columbia River. The paper went to China, and was seen by Americans in Canton before the close of the year.

On the 23d of March Lewis and Clarke started eastward, following at first the route pursued in approaching the Pacific. The company afterwards separated into parties to examine valleys of the Upper Columbia, but the parties were rejoined at the mouth of the Yellowstone, and all reached Saint Louis on the 23d of September, 1806. By this memorable expedition an immense river system and a large section of the American continent were made known to the world. It gave impulse to movements, American as well as English, both by sea and land. Many profited by the facilities pointed out by Lewis and Clarke.

RUSSIAN EXPEDITIONS, 1803-'06.

The first expedition from Russia was sent out at the instance of the Chancellor Count Romanzoff. Two ships, the Nadeschda and the Newa, under command of Capt. A. T. von Krusenstern, sailed from St. Petersburg in August, 1803. The Newa was in charge of Capt. U. Lysiansky, and each vessel pursued its own course, making different explorations in the northern parts of Russian Asia and America in the years 1804 and 1805. With the expedition went as envoy to the Emperor of Japan, the Russian Chamberlain Von Rezanoff. But that Asiatic power strictly maintained its system of non-intercourse with other nations, and declined the proposed mission, and the envoy in consequence was taken to the harbor of St. Peter and St. Paul in Kamtchatka. There some letters from St. Petersburg induced him to visit the Aleutian Islands and northwest coast of America. He was accompanied by the German naturalist Von Langsdorff, who afterwards published a history of the voyage. The passage was made in the galiot Maria, a slow sailing vessel belonging to the Russian Fur Company from Petro Pawowsk. Starting on the 25th of June, 1805, the party passed along the Aleutian Islands, Alaska, and Kadiak, to Norfolk Sound (Sitka), and there arrived on the 7th of September. Baranoff, the governor of the Russian establishments, had some years earlier taken possession, had built a fort at Sitka, and made it the central station of Russo-American dominion, which until then had been at Kadiak. He assembled at Sitka many Russian fur-hunters and Aleutians, and the company was further augmented by the crew of the Maria, who intended to pass the winter in port. But the resources of the young and poorly provided colony could not sustain the dependent number. A disastrous famine ensued; sickness prevailed and threatened the establishment with ruin, when, fortunately, the American vessel Juno, from Bristol, R. I., arrived with a cargo of provisions. These were immediately purchased, but the famine was thereby only averted for a time. At length Baranoff and Rezanoff purchased the American vessel, in order to bring from California what might be indispensable for supporting the colony. The command of the Juno was given to the Russian lieutenants Chwosdoff and Davidoff. Rezanoff and the naturalist, Langsdorff, went with them, and the ship left Sitka for San Francisco on the 8th of March, 1806. The passage was made tedious by sickness amongst the Russian sailors, all of them being sick with scurvy. They nevertheless tried to make some coast examinations, and attempted to enter the mouth of Columbia River, where the Russian plenipotentiary thought of founding an establisment. An opening on the coast, supposed by them to mark the entrance of that river, was examined with boats, but it was soon found to be the inlet which Vancouver had named Gray's Harbor. Some days after (March 31) the Juno was at anchor off Cape Disappointment with a very sick crew. Next day they tried to enter, but observing that the eastern horizon was strongly marked with surf, and having been driven by the currents towards Cape Adams, it was deemed advisable to get away, and take advantage of the favorable northwest wind. They therefore sailed direct for San Francisco, and entered that port on the 8th of April.

The transactions of Von Rezanoff and his officers at San Francisco were mostly commercial and political. At the Spanish mission offers were made to exchange the woolen stuffs and other goods bought with the cargo of the Juno for flour, meat, and vegetables, and to establish by treaty a lasting commerce between the missions and the Russian settlements. They had with them Vancouver's maps, which were found serviceable, and also a tracing of the survey made by La Pérouse at San Francisco Bay. Langsdorff made some useful observations in geography and natural history. He visited the south part of the bay in a boat, and he is the only authority we have in regard to the condition of the Franciscan missions in 1806, and also respecting their undertakings in earlier years.

This expedition is moreover of interest because the Russians, failing in the plan for establishlishing commercial intercourse with the Californians, conceived the idea of planting a colony of their own on the coast. On the 12th of May the party left San Francisco, and without delay returned with their provisions to Sitka, where they arrived on the 20th of June. This was the first Russian expedition to California of which we have accurate information.

FUR COMPANIES, 1806-'21.

The expedition of Lewis and Clarke was noticed with deep interest by explorers and fur-traders. Some existing companies revived and others were organized for prospective gains in the recently opened country.

The Northwest Company, then active and enterprising, had, while Lewis and Clarke were in motion, sent parties towards the Rocky Mountains, and had crossd them in 1793, when their agent, Mr. A. Mackenzie, arrived on the Pacific coast. Another agent, Mr. Simon Fraser, crossed the mountains in 1806 at the source of the river which bears his name, and established a settlement, which was called New Caledonia. Mr. D. W. Harmon traveled as chief agent of the Northwest Company during several years beyond the mountains. Though his book (published in London in 1820) is simply written, it contains interesting information in regard to the country east of Vancouver Island, and of that around the Strait of Fuca, and also the Columbia River. It is in many matters connected with discoveries in that region the only source of authentic information. The map accompanying it is the first on which Fraser River is laid down in its true course.

A Missouri fur company was formed in 1808 for settlements on the Upper Missouri, and one of its agents, Mr. Henry, founded a post on one of the branches of the Upper Columbia, but the post was soon abandoned.

In 1810 Captain Smith, from Boston, entered the Columbia and built a house 40 miles above the mouth, but the house was destroyed within twelve months, as stated in Greenhow's "Oregon and California," page 291.

At the period here under notice John Jacob Astor, of New York, established the Pacific Fur Company. He was a personal friend of President Jefferson, who had originated the expedition of Lewis and Clarke. Mr. Astor enlisted expert Canadian, Scotch, and American travelers and sailors who had been in the service of the Northwest Company. He sent out in 1809 the ship Enterprize, under Captain Ebbets, to make observations at several places on the northwest coast of America; but no detailed account has been given of that voyage.

On the 2d of September, 1810, a second sea expedition, in the ship Tonquin, was sent to the mouth of Columbia River by way of Cape Horn, under Capt. T. Thorne. The best account of this expedition is given in "Adventures on the Columbia River, by Ross Cox." That book details events which occurred in Oregon between the years 1810 and 1816. Another is entitled, "Relation d'un voyage a la cote Nord Ouest dan les années, 1810–1814, par Gabriel Franchere. Montreal, 1820." Ross Cox and Franchere were, for the most part, eye witnesses of what they describe. The first named came to the Columbia by sea, the other went across the Rocky Mountains. A well written account of the operations of the Pacific Company is given by Greenhow.

A land expedition under the chief agent, Mr. Hunt, set out from Saint Louis in January, 1810, going by way of the Missouri River.

An expedition in the ship Beaver, under Capt. Cornelius Sowles, sailed in October, 1811. These were all attended by men expert in their several ways as navigators, scientific observers, and hunters. Ross Cox went as clerk in this expedition.

While the Astorian parties were on their way the Northwest Company also advanced towards the Columbia by sending out (in 1810), by way of the Peace River, a company from Canada under the surveyor and astronomer David Thompson. All these parties arrived successively on the Pacific in what was then called the Oregon country. The English detachments were at the north, the Americans farther south, and especially at the mouth of the Columbia River, where, in the spring of 1811, they built Fort Astoria in the vicinity of the cape named by Broughton Point George.

Thompson explored the region watered by the main branch of the Columbia. He followed part of the route of Lewis and Clarke, corroborated and in some particulars corrected their reports, and gave an improved map of the sources of the Missouri as well as of the Columbia River. Much information in regard to this expedition was given by Washington Irving in his "Astoria, or Anecdotes of an Enterprise beyond the Rocky Mountains. Philadelphia, 1836."

In August, 1812, the ship Beaver was sent from Astoria towards the Russian establishments but the war that ensued between the United States and Great Britain checked the operations of

the Pacific Fur Company. Disasters followed. The ship Tonquin was wrecked and her crew was murdered by savages. The ship Lark, sent from New York by Mr. Astor in the year 1813, was wrecked at the Sandwich Islands, and much suffering was endured by the land parties.

While the agents of the Pacific Fur Company held possession of the fort at Astoria (from June, 1811, until ctober, 1813) several parties were sent out from thence, but all were directed to the upper branches of the Columbia. Mr. Astor intended "to have coasting vessels of his own at Astoria, of small draught of water, fitted for coasting service," but that purpose was not accomplished. The people there were without means for navigating the coast, with which they consequently remained entirely unacquainted, while the interior regions were well known to them. Finally, when threatened by the presence of a British sloop-of-war in the Pacific, the agents of Mr. Astor, on the 16th of October, 1813, sold the fur establishment to the Northwest Company. Only a month after the transfer the sloop-of-war Raccoon, Captain Black, entered Columbia River, the British flag was raised, and the name Astoria was changed to Fort George. After the restoration of peace the fort was again (1818) in possession of the United States. Mr. Astor for a time contemplated the revival of his western projects, but the Northwest Company had in the interval occupied the valley of the Columbia River and its chief tributaries, and were carrying on trade in the neighboring region. Official aid could not be obtained, and without such aid it was deemed impossible to dispossess the intruders.

Citizens of the United States were at this period settling and improving the fertile lands of Ohio and the Mississippi Valley. The distant Pacific region had become less attractive as the sea otters diminished in number; and moreover the fur yearly decreased in price. The Federal Government, however, repeatedly asserted its right to that part of North America.

In the year 1821 the fur companies, after being at enmity as rivals, were united under the name of The Hudson Bay Company, and this union gave strength to the British interest on the northwest coast.

The voyages and travels of Franklin, Richardson, Parry, and others, undertaken by order of the British Government, and favored by the Hudson Bay Company, aided much in geographical development near the Rocky Mountains. New roads were opened to the west, but their views were chiefly directed to the north. In a peaceful way the agents of the company in time occupied nearly the whole Pacific slope between California and the Russian possessions, and all the country drained by the Columbia, Fraser, and other rivers. These agents, says Mr. Greenhow "were now seen throughout the whole northwest, from the Atlantic to the Pacific, hunting, trapping, and trading with the aborigines. Their boats sailed on every lake and river, and their trading posts and fortifications were in every important location. For many years scarcely one American citizen was to be seen west of the Rocky Mountains; nay, they were obliged even to withdraw their vessels from the northwestern coast."

The Hudson Bay Company had their principal residence on the Columbia, in Fort Vancouver, founded in the year 1824, at a considerable distance from the mouth of the river. This became the center of operations in what they called The Columbia Department (now Oregon and Washington), but they established some trading post in every position of importance, from the north, even beyond the Russian settlements, and to the southward at San Francisco and Monterey. They resorted also to the Sandwich Islands. Mr. Astor's idea of a coasting fleet was realized by this company. Small vessels to explore the inlets and ports along the coast were provided, and in the interval between the years 1830 and 1840, they had in service five corvettes of about 300 tons each and a small steamer (the Beaver), besides two larger sea-going vessels for trading between Columbia River and London.

In successive excursions the Canadian hunters extended their trading district from the Columbia southward to the Sacramento, and on their way found several rivers the banks of which were inhabited by distinct tribes of Indians. Some of the names then given to streams are still retained, as Umpquah Klamath, &c. Commodore Wilkes, whose exploring parties from the Columbia River in 1841 partly followed the tracks opened by the Canadian hunters, gives much useful information in regard to this region in his "Narrative of the United States Exploring Expedition," Vols. IV and V. The French traveler, Duflot de Mofras, who was journeying there in the year

1841, made the matter a subject of investigation, and gave much information in his published work entitled "Exploration du territoire de l'Oregon. Paris, 1844."

The Hudson Bay Company sent some parties to explore the lower reaches of rivers which had been crossed by the Canadian hunters, and to build small forts at suitable places. It may be said that at this time they were the only navigating parties on the coast. But the company kept no account of their land operations. De Mofras says that Captain Brotchie, in the service of that company, was very active; he was one of the most experienced officers on the coast, and in the year 1836 made a coasting voyage in the schooner Cadborough to the south of the Columbia River to examine the entrances of the little rivers Sagousta, Killimon, Yacoun, Nehalem, Umpquah, and Klamath. A fort was erected near the mouth of the Umpquah in the year 1837.

An important branch of the operations of the Hudson Bay Company was their exploration at the north, towards the Strait of Fuca and Vancouver Island. In that direction they founded posts after the year 1830. At that time Fort Nisqually was founded at the head of Puget Sound, and in time it became their chief station in that quarter. The eastern coast of Vancouver Island was also at that period further explored and partially settled. Coal was found on the island in the year 1834, and by means of the little steamer Beaver, already mentioned, steam navigation was used for examining the nooks and corners of that vicinity which had not been seen by Vancouver, Valdez, or Galiano.

In the year 1828 Fraser River was for the first time navigated in canoes from its source to the mouth by Sir George Simpson, governor of the territories of the Hudson Bay Company. Other rivers were traced, and in particular the Stikine, which was first examined by the traveler McLeod. These and other streams of the northwest had not been explored by Vancouver. The center of these movements was Fort Vancouver, but animation was given by the company's chief agent in the Columbia district, Dr. John McLaughlin. That energetic man deserves mention in the history of exploration; he crossed the Rocky Mountains with the Northwest Company, and in the year 1824 built Fort Vancouver. It was at his instance that all the enterprises here mentioned were undertaken, and (says De Mofras) to him the Hudson Bay Company owed principally the advancement of their affairs and the extension of their commercial dominion on the Pacific coast. He ruled, so to speak, in those regions for more than twenty years.

RUSSIAN SETTLEMENTS, 1812–'41.

The Hudson Bay Company and the Russian Fur Company so greatly extended their settlements that at one time the two corporations seemed to divide the entire region between themselves.

After the year 1806, when the naval expedition of Rezanoff and Langsdorff came down from the north to San Francisco and attempted to establish there a commercial connection with the Spanish missions, those regions had not been forgotten by the Russians, and as they always needed provisions they concluded to settle at some point on the coast not already occupied, and there cultivate ground on their own account. For this purpose they chose Bodega Bay, north of San Francisco, which had not been reached by the Spanish missions. M. Baranoff, the enterprising Russian governor, sent in the year 1812 an expedition, consisting of one hundred Russians and a number of Aleutians, in a fleet of barks commanded by M. Kuskoff. They sailed from Sitka southward as far as Port Bodega. There they made a settlement, which in course of time extended along the coast nearly 40 miles, and in that stretch were a fort, Russian farm-houses, magazines, chapels, fruit gardens, and ground under cultivation. The Spanish authorities repeatedly protested against this Russian encroachment, but were unable to resist it by force. The Russians consequently retained possession for nearly thirty years. They made yearly boat expeditions from Sitka to Bodega Harbor, and from thence gradually extended their journeys for hunting on land and for taking seal along the coast. They went into San Francisco Bay and killed the sea otter in sight of the Spaniards, who, if able to resist them, had no boats.

In the year 1826 the Russians possessed themselves of the Farallones, where they established a little colony of Kadiacks and held those islands so long as seals and the sea-otter were to be found there. They proceeded south to the Santa Barbara Channel and occupied some of the

islands. The island of San Nicolas is particularly mentioned as the usual hunting ground of the Russians. Captain Beechy and Sir George Simpson make mention of these movements. It appears that the Russians were assisted in some of these expeditions by Boston men or American mariners. In Irving's Astoria, we read: "The American captains engaged in this particular department of west coast trade nsed to come to New Archangel, the principal place of the Russian colonies. Here their ships would be furnished with a little fleet of canoes and a hundred Kadiack hunters, and fitted out with everything necessary for hunting the sea otter on the coast of California. The ships would ply along the Californian coast from place to place, dropping parties of hunters in their canoes, and leaving them to depend upon their own dexterity for maintenance. When a sufficient cargo was collected they would gather up their canoes and hunters and return with them to New Archangel, where the American captain would receive one-half the skins for his share."

The Russians gave to places on the coast names of their own. Bodega Bay was called by them Port Romanzoff; Bodega Head was their Cape Romanzoff; the river San Ignacio they named Avatscha River; the river San Sebastian is their Slavianka River; and the point now known as Fort Ross was in their designation Cape Sievero Zapadnoi, that is Northwest Cape.

As their baidarkas were very small vessels and the Kadiacks expert fishermen, they probably, in the course of those thirty years, gained intimate knowledge of little inlets which had never been seen either by the Spaniards or Vancouver. It is therefore unfortunate that we do not know what names were given to them. It is also to be regretted that their scientific observations and charts of the region are lost, for it can scarcely be doubted that such existed when we read the description given by a French traveler of the cultivated society of talented officers once assembled on the shores of Port Romanzoff.

The Russo-American Company is said to have derived large gains from the southern settlements; and thus the Russian Government was induced to form plans for dominion. One of the Sandwich Islands was seized, and in the year 1821 a ukase issued by which the Russian Government was declared to be in possession of the coast northward of Vancouver Island, and all foreigners were prohibited from approaching within 100 miles. These measures were somewhat like those of the Spanish King who soon after the Middle Ages attempted to make the Pacific Ocean a *mare clausum*. But the protests of the United States and Great Britain against the singular proceeding, and the subsequent treaties between those powers and Russia in 1825 and 1826, made the decree which has been referred to, of no effect. The southern boundary of the Russian empire on the northwest coast of America was finally fixed, and in the year 1841 the Russian Commercial Company gave up their establishments on the coast of California. The good sites for sealing and sea-otter hunting had been exhausted, and the necessity for seeking provisions so far south was removed by the operations of the Puget Sound Agricultural Company, which had cultivated land nearer to the Russian colonies. All the circumstances had changed; another nation was approaching California, and the Russians sold all the property to which they had claim.

MISSIONARY TRAVELS.

The Franciscan missionaries did not extend their explorations in California either along the coast or towards the interior. They were able to do little, as they had not in San Francisco Bay any vessel, or even a boat, at their disposal. When a ship arrived at the Golden Gate it was hailed by a speaking trumpet and was obliged to send a boat on shore to the fort. Expeditions to the eastern side of the bay were made on horseback round the basin, and the rivers were examined in the same manner. This appears almost incredible, yet Vancouver in 1792, as well as Langsdorff in 1806, and others mention what has just been stated. From this it may be concluded that nothing could be done at that time for the hydrography. Langsdorff says (in 1806) that Spaniards had traced the river Sacramento nearly 90 leagues, but only along one of its banks, never having been able to examine the right bank for want of boats. Of the source of the river nothing was known, and even the sea entrance was doubtful. But land excursions were made yearly from the principal Spanish posts, Monterey, San Diego, and San Francisco, to procure Indians for service at the missions; and at the same time efforts were made to Christianize them. These jour-

neys of course tended to enlarge knowledge in regard to the territory. Some appear to have been made for establishing communication between Santa Fé, in New Mexico, and the upper coast of California. In 1785 the Governor of that province, Don Pedro Fages, had proposed an expedition from Monterey, or the river of San Francisco, to the east, with a view of communicating with the province of New Mexico. It seems that now and then a journey was made expressly for discovery. Thus we read that in the year 1811 two Franciscan friars, the Fathers Fortuni and Abello, traveled along the course of the San Joaquin River and explored its valley, excepting the upper parts. No doubt the history of these excursions would be interesting, but no writers such as Fathers Crespi, Palon, and De la Pena were left in California to make journals.

Langsdorff says that while he was at San Francisco a sergeant and corporal with thirteen soldiers arrived from the east, having just returned from travel. They asserted that they had penetrated into the country between 80 and 90 leagues, and had reached the vicinity of the Sierra Nevada. In the same direction another party went soon after under Don Luis Arguello and Father Joseph Uria.

CAPT. F. W. BEECHY, 1827.

While continental war continued in Europe the British Government gave no attention to the question concerning a northwest passage from the Atlantic to the Pacific, but after the year 1816 the subject was again taken up. Maritime parties explored Baffin's Bay, including its northern branches and inlets. In 1821 Captain Parry sailed into Lancaster Sound, and went westward somewhat farther than either of the navigators who preceded him. After his return a combined land and sea expedition was planned, and he was again sent to Lancaster Sound, with directions to pass on westward, if possible, to Bering Strait. Captain Franklin went overland through the central parts of Arctic America to explore the coast of the frozen sea. It was, moreover, resolved to send a ship through the Pacific to Bering Strait to supply Captain Parry, if he shou d arrive there, with provisions, and to bring home the land party of Captain Franklin. The ship Blossom was selected for the service, and Captain Beechy was assigned to command. As the estimated time of arrival at the strait was ample, he was instructed to explore and survey parts of the Pacific deemed most important for navigation and within reach of his intended course. The ship was therefore fitted with appliances for surveying, and was accompanied by several officers of ability, one being Lieut. Edward Belcher. Only general directions were given in regard to the exploration of our coasts, and discretionary power was allowed in the choice of places for procuring provisions and water. So also in regard to the return voyage, of which liberty Captain Beechy so availed that he made a prolonged stay on the coast of California, and on his way home passed along the shores that had not been visited by any scientific expedition since the time of Vancouver. His instructions included that particular note should be made of the differences of longitude as given by his chronometers.

Captain Beechy made the "Highland of New Albion" on the 5th of November, 1826, as he was returning from his visit to Bering Strait. He passed with Bodega and Point Reyes in view, and soon entered San Francisco Bay, where, by sounding, he discovered some dangerous rocks, one of which he named after his ship Blossom Rock. Without delay he sounded and completed a survey of the port and bay, and by astronomical observations corrected the position of the place. He then proceeded to Monterey, where he was for a time occupied in a similar way. On the 5th of January, 1827, he sailed for the Sandwich Islands. In the course of the same year, on his return voyage to Europe, after a second summer sojourn at Bering Strait, Beechy was again in San Francisco Bay, and also at Monterey, but only for a few days in November and December. In the report of his voyage he treats at length on the Spanish missions, and in regard to the Indians of California. Beechy's determinations for geographical position compare well with the final results reached in the operations of the Coast Survey.

SIR EDWARD BELCHER, 1836-'42.

The British Government previous to the year 1836 had been active, and several expeditions were sent to explore the coasts of America. Captain King and Captain Fitzroy, in the ships

Adventure and Beagle, were occupied nearly ten years (1826–1836) with the survey of the Strait of Magellan and the adjacent southern part of the western coast of South America.

In December, 1835, another expedition was ordered by the Lords of the Admiralty, to continue the survey of the western coast of America north of the point where it was discontinued by Fitzroy.. "The impulse which American commerce had received from the revolutions in the Spanish colonies had brought English vessels into contact with every port from Valdivia in the south to Columbia River in the north, and particularly the western American commerce had long been in need of good charts." Two vessels, the Sulphur (British sloop of war) and the schooner Starling, were therefore fitted out, and Captain Beechy, who had been on the western coast, was placed in charge of the expedition. The Starling was intrusted to the command of Lieutenant Kellet. Captain Beechy conducted the voyage as far as Valparaiso, but being constrained to return to England as an invalid, Captain Belcher was commissioned to replace him, and after crossing the Isthmus of Panama, Belcher joined the squadron on the Pacific in February, 1837. He sailed at once by way of the Sandwich Islands, and from thence reached Prince William Sound in August. His instructions directed that "a general chart should be made of California," and he was advised "to devote some time to the bar of Columbia River, and to its channels of approach, as also to its inner anchorages and shores." In touching the district visited by Vancouver (called the northwest coast) care was to be taken to verify the longitude at two or three of Vancouver's principal points which differ materially from the longitudes assigned by Señor Quadra and the Spaniards. From the latitude of Mount Saint Elias "the survey again might be pursued to the southward and along to the shores of Mexico and Guatemala alternately changing the ground according to the periodic change of weather." In accordance with these instructions, which gave liberty in regard "to the selection of ground and in respect of the division and disposal of his time," Belcher extended surveying operations twice along the northwest coast from Mount Saint Elias to Cape San Lucas, once in the summer of 1837 and again in the summer of 1839. As already stated he was in the latitude of Mount Saint Elias in August. He passed some time near the Russian settlements, and early in October was at Nootka, where he found an Indian prince named Maguilla or Maguinna, a descendant of the former chief of that name. From thence he went southward, passed the Columbia River entrance, as the weather was boisterous, and kept on to San Francisco, where he dropped anchor in Yerba Buena Bay on the 19th of October.

San Francisco Bay had been explored by himself and Captain Beechy in the year 1827, when they were in the ship Blossom, but that survey was ended at Karquines Strait. On the 24th of October Captain Belcher started from Yerba Buena with the tender Starling, a pinnace, two cutters, and two gigs, to explore the navigable channel of the Rio Sacramento. He carried the Starling in as far as Suisun Bay, and with his boats in the course of five days ascended the river about 150 miles, including the curves of the channel. The limit of progress with boats he named Victoria Point. In returning he made a trigonometrical survey of the course of the river and was thus engaged during twenty days. On the 24th of November he again reached the ship Sulphur, and ten days afterwards arrived at Monterey. Only a few days previous to his arrival the French frigate La Venus had cleared from that port. On the 11th of December, Captain Belcher passed near Guadalupe to land, and on the 16th reached Cape San Lucas, where he closed his first surveying cruise along the coast of California.

During the two subsequent years Belcher was occupied on the coast of the Pacific more to the southward, but he returned by way of the Sandwich Islands in the spring of 1839, and was at Sitka early in July. Near the close of that month he entered Columbia River and surveyed its course and channel up to Fort Vancouver. Two months were occupied in that work. The channel at the south entrance he called Queen's Channel. On the 14th of September he left the river, but on the way, toward San Francisco, he sent Lieutenant Kellet with the Starling into Bodega Bay with directions to complete a survey. The report mentions that the work was done "as soon as the fog permitted."

On the 5th of October Belcher reached Monterey, and on the 7th was in the Santa Barbara Channel. Partial surveys were made off the anchorage and at the approaches to San Pedro Bay. From thence the Starling was dispatched to examine the island and anchorage of Santa Catalina. Belcher meanwhile visited the harbor of San Juan and San Diego Bay. He made a careful

survey of the last-mentioned bay, and near the close of October left the coast and never returned. Kellet was there again in command of a surveying vessel, and in the year 1847 made some surveys in the strait of Fuca, the results of which are given on the admiralty charts.

FRENCH EXPLORATIONS, 1820–'42.

Mention has already been made of the French voyages to the northwest coast under La Pérouse and Marchand. After these, the French revolution restrained maritime action in the Pacific, but on the restoration of the Bourbons, or soon following that event, sea enterprises were resumed. Each voyage doubtless had some influence in geographical development, but it would be needless to trace them without access to the separate narratives, even if such narratives were in existence. In chronological order they were—

1. A voyage around the world by Roquefeuil in the year 1820.
2. A voyage around the world in the frigate La Coquille.
3. A circumnavigation of the globe in the frigate La Thétis and the corvette l'Esperance, in the years 1824–'26, under Baron Bougainville.
4. A circumnavigation of the globe in the corvette La Favorite in the years 1830–'32, under command of M. La Place.
5. A voyage around the world in the years 1836 and 1837, in the corvette La Bonite, commanded by M. Vaillant, Captain de Vaisseau.
6. A voyage around the world in the frigate La Venus, 1836–'39, by Abel du Petit Thouars.
7. A circumnavigation of the globe by the frigate La Artemise in 1837–'39, under command of M. La Place.
8. A voyage around the globe in the corvette La Danaide, commanded by Capt. D. Rosamel, in 1839 and 1840.

Most of these expeditions touched at the usual places and ports of the North Pacific explorers, China, the Sandwich Islands, and California.

Between the years 1837 and 1840 there was annually a French expedition in the harbor of Monterey. All of them made observations occasionally, and some surveys of harbors, capes, and bays.

As the most interesting of these voyages in relation to California, we may point out those of Du Petit Thouars (1837), La Place (1839), and Rosamel (1840).

French or Canadian missionaries also who traveled in the Oregon country advanced the knowledge of its geography by publication. The journey of Blanchet and Demers, in 1838, was one of that kind, when they founded several Roman Catholic missions amongst Canadian settlers on the shores of Columbia River.

During the excitement incident to the contested possession of Oregon the French Government sent M. Duflot de Mofras on a diplomatic mission to Mexico (1840–'42) with instructions to visit the western and northwestern provinces of Mexico, Upper and Lower California, the Russian establishments, and the Oregon Territory. He traveled in each of the places indicated, and on the coast met the United States Exploring Expedition under Captain Wilkes. De Mofras collected much interesting information, and gave the results in a well-written work. He gives particulars respecting the journeys of the French Canadians under the auspices of the Northwest and Hudson Bay Companies, and regards them as French explorations. They may be so called, as the French began the march of discovery from the Saint Lawrence towards the Pacific. By their help as subjects of England the British company brought that movement to a satisfactory conclusion.

The voyage of Captain Rosamel and the land expedition of De Mofras to California were the last which can be properly named as French undertakings in that direction.

UNITED STATES EXPEDITIONS 1820–'47.

After the unfortunate experience of the Pacific Fur Company, citizens of the United States for a time lost sight of the far northwest. A pause of some years ensued, but at length attention was directed southwest, to the head of Colorado River, to New Mexico, and occasionally to the southeastern branches of Columbia River, where they were not likely to come in contact with the Hudson Bay Company. It will suffice to point out the progressive steps taken in that direction.

In the year 1820 Maj. Stephen Long went to the Rocky Mountains, to the heads of the Platte and Arkansas Rivers, and to New Mexico. Regular trade was soon established between the Mississippi and Rio Colorado, between Saint Louis and Santa Fé. Nearly every summer after the year 1823 large caravans passed between those two places, and many American trappers and hunters arrived at different points on the Upper Colorado. Of these the most successful was Mr. W. H. Ashley, who conducted or sent in the period between 1823 and 1827 several bodies of trappers, with horses, beyond the Rocky Mountains to the headwaters of the Colorado and Columbia Rivers. From thence he made several excursions westward, and sent detached parties to different branches of the western waters. He discovered the South Pass, and was the first American who saw Utah Lake and Green River and other branches of the Colorado. Mr. Ashley was succeeded by Messrs. Smith and Soublette, who bought his interests and pushed operations beyond the Rocky Mountains, and also along the southeastern branch of the Columbia, in the years 1827 to 1829. Mr. Smith was the first American who traversed central California from the Rocky Mountains towards the San Joachin River, San Francisco, and the Pacific; but he recorded no astronomical observations. He was murdered in the year 1829 by Indians near Utah Lake. On his map of the northwest De Mofras approximately represents the route taken by Mr. Smith.

In the years 1828 and 1829 another American traveler, Mr. Pilcher, a member of the American Fur Company, followed the southern branch of the Columbia, journeyed along the northern branch, and returned by the Athabasca and Red Rivers.

Excursions for hunting and trapping were made in 1832 and 1833 by Mr. J. O. Pattie and Captain Bonneville. They first traversed the Colorado country and California, and Bonneville "led a band of more than a hundred men, with wagons, horses, and mules, from Missouri to the countries of the Colorado and Columbia, in which he passed two years in hunting." About this time Captain Wyeth formed a scheme similar to that of Mr. Astor for establishing trade between China, Eastern Asia, and the United States by way of the Columbia River, and for that purpose he organized the Columbia Fishing and Trading Company. A ship was sent to Columbia River, and a party was arranged to carry by land goods and men across the mountains. With the men Wyeth went in person, and established a port at the mouth of Willamette River. But it was soon abandoned, as the Hudson Bay Company, by peaceful opposition, counteracted all his efforts to retain the place. His journals and a narrative of his adventures have been published.

In the year 1834 the first body of American emigrants settled in the Columbia region, and were conducted by the Methodist missionaries, Lee and Sheperd. Other religious associations became active. In 1835 the Rev. Samuel Parker made a journey to Oregon, and was followed by Roman Catholic as well as Protestant missionaries.

American trappers, hunters, and fur-traders were steadily traveling and trading at the south; also in the neighborhood of the Colorado and towards California on paths opened and beaten by Ashley, Smith, Pattie, and Bonneville. In this way the attention of the Government of the United States became directed to the Pacific slope, on which citizens had established large interests. In furtherance of them Mr. Forsyth, Secretary of State, in 1836, proposed the first official exploring expedition westward. In November, 1835, President Van Buren accordingly directed William A. Slacum, an officer of the United States Navy, to proceed to the western coast and endeavor "to obtain there all such information, political, physical, statistical, and geographical as might prove useful or interesting to the Government." The instructions and particulars of the voyage are given in Senate Doc. No. 24, second session, Twenty-fifth Congress.

Mr. Slacum traveled through Mexico to Guaymas, and left that port on the 1st of June, intending to reach the Columbia River by land. In Sonora he bought mules and provisions, but was compelled to abandon the journey, being informed by Dr. Keith, who had just then come from the north, that the land route to Oregon was impracticable at that season of the year. Slacum returned to Guaymas, chartered the Loretano, a vessel of 12 tons, and in her set sail, on the 7th of July, for the Columbia River entrance. After being at sea nineteen days and making only 400 miles he was, near Cape San Lucas, forced by furious head winds to put into Mazatlan in distress and there abandon the schooner. An English barge, the Falcon, was then at La Paz, in Lower California, and about to sail for the Sandwich Islands. Slacum took passage, hoping to get from thence to his intended destination. He reached the Sandwich Islands on the 5th of

November, and there chartered the American brig Loriot, sailed and arrived at the mouth of the Columbia on the 22d of December, 1836. His purpose was to explore the river as far as practicable, then pass along the coast to the Russian settlement at Bodega, and, leaving the vessel, to cross the Indian country on his return to the United States. Slacum made some useful observations. He sounded and plotted a chart of the mouth of the Columbia, and added sailing directions. He procured charts and sketches from the officers of the Hudson Bay Company, and from them compiled a map of the coast and country south of the Columbia. Four rivers appear on it, namely, the Klamet, Rogues, Cowis, and Umpquah. These had never before been laid down on any published map. Slacum gathered some facts of interest relating to the history of the establishments of the Hudson Bay and Russian Fur Companies, and then crossing the continent he returned to the United States.

UNITED STATES EXPLORING EXPEDITION 1838-'41.

On the 18th of May, 1836, an act of Congress authorized the President of the United States to fit out an expedition for exploring the South Sea, and determining the position of Pacific islands and countries lying near the track of American vessels. Six vessels were made ready, namely, the Vincennes, Peacock, Porpoise, Relief, Sea Gull, and Flying Fish, and under command of Lieut. Charles Wilkes, U. S. N., the fleet sailed from Chesapeake Bay on the 18th of August, 1838. He was directed to be at the Sandwich Islands in the spring of the year 1840, to sail from thence to the northwest coast of America, and "make there such surveys and examinations, first, of the territory of the United States on the seaboard, and of the Columbia River, and afterwards along the coast of California, with special reference to the bay of San Francisco, as he could accomplish, until the month of October following his arrival." Special attention was to be given, when practicable, in regard to the geography and hydrography of the various places visited.

Lieutenant Wilkes was detained in the southern part of the Pacific Ocean a year longer than was contemplated when the instructions issued. The Sea Gull was wrecked. With the Vincennes and Porpoise he left the Sandwich Islands on the 5th of April, 1841, the last-named vessel being in charge of Lieut. C. Cadwallader Ringgold. The Peacock and Flying Fish had been sent under Capt. William Hudson from the Sandwich Islands to explore parts of the Pacific, with directions to join the chief of the squadron at the Columbia River by the end of April, 1841.

Wilkes arrived there on the 28th of April with the intention of entering, but the sea on the bar was heavy, and he concluded to sail for the Strait of Fuca, and there begin surveying operations. He entered the strait on the 1st of May, and, following the track of Vancouver to Port Discovery, Port Townsend, and Admiralty Inlet, hastened to the anchorage at Nisqually, where the Hudson Bay Company had an establishment, and there moored his ships on the 11th of May. For upwards of eight weeks he made that his station, and organized surveying parties which were sent out in different directions. To the north Ringgold was sent in the Porpoise with two boats to take up the survey of Admiralty Inlet, proceed to Fraser River, and as far as Johnstone's Inlet. Four boats were intrusted to Lieutenant Case for the survey of Hood's Canal and Puget Sound.

A land party was sent under Lieutenant Johnson to the east, with directions to land and explore the interior as far as the Cascade Mountains and the middle reaches of the Columbia River.

Lieutenant Wilkes in person conducted a party overland south to the Lower Columbia, to start a survey by the crew and boats of the Peacock, that vessel being due from her cruise at the south. All the parties moved about the middle of May, leaving Lieutenant Carr in charge of the ship station near Nisqually and of operations at the observatory which had been erected there. The two land parties recorded observations of interest, but of course none bearing on hydrography. Attention will therefore be limited to the ship expeditions. The survey of Hood's Canal by Lieutenant Case was satisfactory. The canal was not found to terminate at the place supposed to be its end by Johnstone (Vancouver's lieutenant) in 1792, but to stretch, after a short turn to the east, 10 miles farther towards Puget Sound.

Lieutenant Case then surveyed Puget Sound, and was soon joined by Captain Wilkes. The joint party had seven boats with efficient crews, and the survey of the numerous branches of the

sound was completed in the course of a week. Several inlets, not named on Vancouver's chart were at this time named for officers of the United States Exploring Expedition, as Budd's Inlet, Eld's Inlet, Totten Inlet, &c.

On the 17th of July, all the parties excepting the one with Ringgold in the Porpoise were again at the station near Nisqually; and a company was organized for the survey of Gray's Harbor and Shoalwater Bay. Lieutenant Eld was intrusted with that work. After his departure the Vincennes also left Nisqually, and, steering northward, took another station near Dungeness, in the Strait of Fuca, on the 20th of July. Ringgold, on the same day, returned from his northern survey. He had left Nisqually on the 15th of May and commenced work in Admiralty Inlet. The space then sounded he named Commencement Bay, as it had been left nameless on Vancouver's chart. From thence Ringgold went north, surveying and naming many points and indentations on his way. On the 20th he entered the Port Orchard of Vancouver, and surveyed it in the course of nine days. It was found to communicate at the north through a strait with another bay or branch of Admiralty Sound (Port Madison) which had been overlooked by Vancouver in his short visit to that vicinity.

Ringgold then entered what had been called by Vancouver Possession Sound, and surveyed Port Gardner, Penn's Cove, &c. On the 18th of June he was at Deception Passage, which Vancouver judged to be insufficient for the passage of ordinary vessels.

Early in July all the bays and islands northward of Deception Passage were surveyed as far as Fraser River, and from that entrance Ringgold returned and joined the Vincennes at New Dungeness on the 20th of July, after laborious operations which occupied his party two months.

It was the intention of Captain Wilkes to survey minutely the Gulf of Georgia. Accordingly, as soon as practicable, he sent the Porpoise, under charge of Ringgold, to Fraser River with directions to sail from thence through Johnstone's Strait around Vancouver Island, while Wilkes himself should explore the Haro Canal. Both parties started on the 25th of July. But these operations were interrupted by the loss of the Peacock on the bar of Columbia River. It became necessary to proceed to that place without delay. Captain Ringgold was recalled from Fraser River to New Dungeness and Wilkes hastened with his boats, having completed all that "was essential for the navigation of Canal De Haro."

Both vessels took courses westward, surveying on the way two small harbors, San Juan, on the south side of Vancouver Island, and Neeah, near Cape Flattery. They arrived at the mouth of the Columbia on the 7th of August, where an English vessel was purchased to receive the crew of the wrecked ship Peacock. The craft was named the Oregon, and needful arrangements were made for continuing the objects of the expedition. Under Ringgold the Vincennes was sent to survey San Francisco Bay and the Sacramento River.

A large land party in charge of Lieutenant Emmons was sent to travel from the Columbia along the Willamette; to examine also the Sacramento and San Francisco Bay; and Wilkes, with the Porpoise, the Flying Fish, and the boats saved from the wreck of the Peacock, commenced the survey of the Columbia on the 9th of August.

Mr. Eld and his party had left Nisqually on the 19th of July, and traveling through the interior passed several lakes and rivers, mostly branches of the Chikeeles, a tributary of Gray's Harbor, where they arrived early in August. The survey of that vicinity, by means of boats and the canoes of neighboring Indians, was completed in the course of three weeks. Lieutenant Eld subsequently traced the coast southward to Cape Disappointment, and passing Shoalwater Bay in a canoe reached Baker's Bay on the last day of August. His performance of duty is specially commended in the report of Captain Wilkes. The commander himself was employed on the Columbia during August, September, and part of October, and the survey was carried to the vicinity of the cataracts. On the 10th of October, when the operations were finished, Wilkes crossed the bar of the Columbia and sailed in the Porpoise to San Francisco. The Flying Fish was at the same time ordered to examine the lower part of Umpquah River, but the attempt to enter was not successful. On the 19th of October the Porpoise reached Saucelito Harbor in San Francisco Bay, and there the Vincennes was found at anchor. Ringgold had arrived on the 14th of August and surveyed the Sacramento as far up as Feather River. He had also examined San Pablo Bay and the mouth of the San Joaquin. The party under Mr. Emmons arrived in San Francisco Bay on

the 28th of October, having followed and surveyed the trail from the Columbia River. Some of the intervening rivers were seen and the party examined the valleys, particularly those of the Elk, the Umpquah, Rogue, and Klamath Rivers.

All the exploring parties having returned, preparations were made for sailing from San Francisco with the first fair wind. The latitude of Saucelito Fort, where an observatory had been erected, was found to be 37° 50′ 50″ N., and the longitude, by a series of observations on moon culminating stars, 122° 25′ 36″ west of Greenwich. These determinations are in tolerable accord with those of Beechey, and were used provisionally by the officers of the United States Coast Survey at the outset of their operations.

The exploring expedition left San Francisco on the 1st of November, intending to sail to the Philippines. Captain Wilkes went south as far as the Bay of Monterey. The Porpoise was sent with dispatches for Washington, D. C. As the principal hydrographic results of the expedition we may point out the examination and survey of the lower reach of the Columbia River, the survey of Gray's Harbor, the Strait of Fuca, Admiralty Inlet, and the Haro Archipelago; also of the Bay of San Francisco and Sacramento River. Close examinations were found impracticable at the Gulf of Georgia, at Vancouver Island, and along the coast between Columbia River and the Golden Gate, weather being unfavorable.

OREGON AND CALIFORNIA. 1842–1846.

Capt. John Charles Fremont's first expedition to the West, in the year 1842, was limited to the country between the frontiers of Missouri and the South Pass of the Rocky Mountains, along the courses of the Kansas and Great Platte Rivers. Subsequently he recorded observations for latitude and longitude from the east across to the foot of the mountains. His western limit was the high peak which bears his name on maps published since that journey.

In the spring of 1843 Fremont again went westward, with instructions from the Bureau of Topographical Engineers "to connect his reconnaissance of 1842 with the surveys of Commander Wilkes on the coast of the Pacific Ocean, so as to give a connected survey through the interior of the North American continent."

Mr. Fremont was accompanied on this expedition by an able engineer and draughtsman, Mr. Charles Preuss, and provided with good instruments for determining geographical position, time, temperature, &c. His course was at the outset directed toward Oregon. In August, 1843, he reached the heads of the south branch of Columbia River, and passed down to Fort Vancouver, where he arrived in November, and in accordance with instructions his reconnaissance was there connected with the surveys of Captain Wilkes. Fremont was prevented by the rainy season from going quite to the Pacific; so, returning to the Dalles of the Columbia, he passed from thence southward into the country along the Cascade range of mountains and the Sierra Nevada. Crossing the head of the Klamath the party at the close of the year were near the mountains, and circumstances constrained him to attempt to cross them in midwinter. Under many difficulties and dangers the party in the beginning of February reached the snowy peaks, "and saw from thence below them, dimmed by the distance, a large snowless valley, bounded on the western side, at the distance of about 100 miles, by a low range of mountains, which were recognized as those bordering the coast." Between them and the low coast range was the valley of the Sacramento. Soon after water was seen flowing towards the Pacific, and "a shining line of water was discovered directing its course towards another broader and larger sheet," which were "the Sacramento and the Bay of San Francisco." In the spring of the year 1844 the party traveled from the Lower Sacramento, along the western slope of the Sierra Nevada, through the valley of the San Joaquin. Fremont returned in a northeastern direction to the Rocky Mountains, and so again reached the banks of the Mississippi. His observations on that part of his route—"from the heads of the Sacramento to the heads of the San Joaquin, and the valley which collects all the waters of San Francisco Bay, proved that there was no such river as the fabulous Buenaventure, which had been said to come down from the base of the Rocky Mountains and to open a communication with San Francisco Bay, far to the interior." He adds:

"This want of interior communication from San Francisco Bay, now fully ascertained, gives

great additional value to the Columbia, the only great river on the Pacific slope of the continent which leads from the ocean to the Rocky Mountains, and opens a line of communication from the sea to the valley of the Mississippi."

On his third expedition, in 1845 and 1846, Frémont traversed the central parts of the great interior basin, passed the Sierra Nevada at the southern end of the range, crossed the San Joaquin Valley, went to the south end of San Francisco Bay, and passed up the valley of the Sacramento to the heads of that river and to the sources of the Klamath. His large map of Oregon and Upper California was published by order of the United States Senate in the year 1848.

In reference to geographical positions Mr. Frémont remarks that the line of astronomical observations carried by him across the continent reached the Pacific Ocean on the northern shore of the Bay of Monterey, and that when the newly established positions were marked on the map it was found that they carried the line of coast about 14 miles west of the longitudes given by Vancouver, and the valleys of the Sacramento and San Joaquin about 20 miles east of the longitudes laid down on former maps. Comparison showed that the positions agreed with the observations of Captain Beechy and Captain Belcher, and also with those of the Spaniard Malaspina. "Vancouver (says Frémont) removed the coast line as fixed by Malaspina, and the subsequent observations carry it back." That remark, however, needs qualification. Coast survey determinations fix the coast about midway between the positions assigned by Malaspina and Vancouver.

MAJ. W. H. EMORY, U. S. CORPS TOPOGRAPHICAL ENGINEERS, 1846-'47.

In the year 1846 a detachment of United States troops was sent to operate in the northern provinces of Mexico and California. As the route was through unexplored regions, it was suggested that some of the officers "should be employed in collecting data which would give the Government an idea of the region traversed." For this purpose a party of topographical engineers went under the command of Lieutenant, afterwards Major, Emory, with orders to perform military service, in case of necessity, under Colonel Kearny.

The party was furnished with two chronometers, two Gambey sextants, and other instruments, with which astronomical observations were made between Saint Louis, on the Mississippi, and San Diego, in California.

Lewis and Clarke, in the year 1806, were the first Americans who carried astronomical instruments across the Rocky Mountains and connected that part of the western coast which lies near the mouth of the Columbia with the Mississippi region by a chain of observations. And, as previously stated, in the year 1813 Mr. Thompson, astronomer and surveyor of the Hudson Bay Company, connected the northern parts of the Columbia with the region around Hudson's Bay. In the course of nearly three hundred years it had been crossed by Coronado and by the early missionaries; but Emory marked the first well-defined line through those regions and developed the physical features of a country until then but little known. He adopted the meridian of Fort Leavenworth as determined by Mr. Nicollet, and to it referred all his subsequent determinations for longitude.

At the end of June, 1846, Major Emory started from Leavenworth, carried on a nearly uninterrupted series of observations for latitude and longitude, and on his route fixed the positions of one hundred and twenty places, all of them determined by repeated observations, and some, when a longer stay in camp permitted, by series of combined observations. At San Diego, where he arrived in December, 1846, his longitude determinations were compared with those of Sir Edward Belcher, and were found nearly accordant. All the geographical positions ascertained by Major Emory were laid down on a map which was published in the year 1847. That officer also recorded a series of barometrical observations, and these availed for an approximate profile of the ground surface along the route. The altitudes of the "divides" and passes near the southern section east of San Diego were found to be about 3,000 feet. Previously the heights had been roughly estimated by mariners at a distance, merely from eye-sight. Subsequently Major Emory traced the southern boundary line of the United States. The initial point then fixed on the

Pacific coast has been adopted, in respect of the latitude and longitude, in the operations of the Coast Survey. Having brought down the history of development to the inception of that work, the reader is referred to the annual reports of the Superintendent of the Survey.

Titles of copies of maps of the Pacific coast of North America or parts thereof.

[Collected by Dr. J. G. Kohl to illustrate his history of discovery and exploration on that coast.]

	Description of map.	Year.
	Maps of the west coast before the discovery of California or before Cortes:	
A	From a manuscript map of the British Museum	1530
B	Mexico and Japan	1540
C	Rotz's Mexico and California	1542
	Maps between 1530 and 1579, or from Cortes to Drake:	
1	From a map of Domingo del Castillo	1541
2	A Portuguese map of California, by J. Freire	1546
3	The coast of California, by J. Freire	1546
4	From the New World, of T. Gastaldi	1560
5	From a map of Bologuini Zaltieri	1566
6	Mexico and California, by Diego Homem	1568
7	California, from a map of Juan Martines	1578
	Maps of the Northwest coast between 1579 and 1697, or from Drake to the Jesuits:	
1	From a map of California, by M. Lock	1582
2	From a map of Molineux	1592
3	From a map of C. de Judaeis	1593
4	From the great map of the world of Hakluyt	1598
5	Map of the discoveries of Viscaino	1602 1603
6	California, by Sanson	1656
7	The Californian Gulf, by Coronelli	1691
8	Map of Western America and Eastern Asia, or "The Country of Yesso," by the Dutch geographer Lugtenberg	1706
	Maps of the period between 1697 and 1769, or from the Jesuits to the Franciscans:	
a	Map of the discoveries of Father Kino	1698 1701
b	From a map of the River of the West by Bellin	1748
c	Map of the supposed discoveries of De Fonte, by P. Buache	1750
d	A Spanish map taken by Anson in	1743
	and published by Venegas in	1757
e	Copy of the same map as published according to act of Parliament, by Jefferys in	1753
f	From a map published by the Academy of St. Petersburg	1758
g	From a map of California by Don Antonio Alzate	1772
	[NOTE.—With reference to this map, Dr. Kohl observes that it may serve to show the knowledge of the West coast which the Mexicans in general possessed of it just before the discoveries of the Franciscan friars.]	
h	The Northwest coast, from a map of J. N. Buache after Engel and Vaugondy	1775
	Maps and charts between the years 1768 and 1794, or from the first voyages and travels of the Franciscan friars to Vancouver:	
1	Chart of Upper California, by Miguel Constanso	1770
2	Copy of a map of the Northwest coast which was constructed after the expedition of Heceta and Bodega	1775
3	Map showing results of combined sea and land expedition round the Bay of San Francisco under Quiros and Moraga; also the route of Father Junipero Serra	1776 1777
	[NOTE.—Dr. Kohl observes that one of the most interesting features of this map is that it is the first which shows the whole of the Bay of San Francisco.]	

Titles of copies of maps of the Pacific coast of North America or parts thereof—Continued.

	Description of map.	Year.
4	From Cook's map of the northwest coast	1778 1779
5	From a map of the English geographer Barrington, on which are combined the discoveries of the Russians, of Bodega, and of Cook	1780
6	From a map by M. A. Mascaro, showing discoveries and travels in the interior of California	1782
7	From a map of the survey and voyage of La Pérouse	1786
8	From a Mexican chart, showing the settlements and travels of the Franciscan missionaries	1787
9	Part of Dixon's map of the northwest, showing his discoveries to the north of Vancouver Island	1787
10	From a chart made by Captain Meares, showing his discoveries on the coast of Vancouver Island, and of Washington and Oregon Territories	1790
11	From another chart of Captain Meares	1790
12	De la Borde's map of comparison, combining and comparing the surveys of Cook (1778), La Pérouse (1786), Dixon (1787), and of Meares (1789)	1792
13	From the map of Captain Marchand	1792
14	From a general chart composed by Don Juan Francisco de la Bodega	1791
15	Map of Vancouver Island, by Captain Ingraham	1792
16	From a map of the coast of California and Oregon by Ingraham, from data supplied by Captain Gray	1792
17	From a map showing Vancouver's discoveries on the northwest coast	1792 1794
18	Quadra and Vancouver Island, after Vancouver	1792
19	Vancouver Island, after Galiano and Valdes	1792
20	From Vancouver's survey of the whole coast of New Albion, or Upper California	1792 1794
21	California, from a chart of Galiano and Valdes	1802
	MAPS FROM 1794 TO 1850.	
22	"Entrada de Juan de Fuca," from a Spanish admiralty chart	1795
I	California, from Tanner's map	1829
II	Map showing the extent of Captain Belcher's surveys on the west coast	1837 1839
III	Map of M. Duflot de Mofras, showing the routes of the Canadian trappers and hunters from the mouth of the Columbia River to the Sacramento	1844
IV	Map of the United States Exploring Expedition, under Captain Wilkes, U. S. N	1841
V	From a map published by De Mofras in his atlas, showing the coast from Bodega Harbor northward, as derived from Russian sources	1840
VI	Copy of Greenhow's map of the west coast	1844
VII	Copy of a map of part of the west coast, made by Lieut. W. P. McArthur, U. S. N., Assistant, Coast Survey	1850

[NOTE.—Accompanying the collection of maps above enumerated is a general map, compiled by Dr. Kohl, and similar in character to those compiled by him for the coasts of the Atlantic and Gulf of Mexico.]

APPENDIX No. 17.

DESCRIPTION OF A MODEL OF THE DEPTHS OF THE SEA IN THE BAY OF NORTH AMERICA AND GULF OF MEXICO.

By J. E. HILGARD, Superintendent.

The systematic deep-sea explorations which were commenced in the Gulf of Mexico in 1872, and which in subsequent years were extended over the entire Gulf Stream region, were brought to a successful issue in the early part of 1883 by the examination of the western part of the Atlantic, limited by the Newfoundland Banks on the north and Windward Islands on the south, and for which I have proposed the name "Bay of North America." This part of the ocean, as the home of the Gulf Stream, has for a long time back attracted more than its proportionate share of scientific interest; and its proximity to the coast of the United States also appeared to demand a more special examination than was accorded to it by the Challenger expedition.

In order to obtain a comprehensive view of these explorations, which should show the prominent results in a conspicuous manner, Messrs. A. and H. Lindenkohl, at my request, constructed an excellent relief model including the Gulf of Mexico, the Bay of North America, part of the Caribbean Sea and West India Islands, and part of the adjacent continent, as far north as the Great Lakes, and west to the plateau of Mexico and nearly to the base of the Rocky Mountains.

In view of the great attention and favorable comment which this model elicited wherever it was exhibited, notably at the London International Fisheries Exposition and at the Philadelphia meeting of the American Association for the Advancement of Science, a short description of it will be of interest.

The horizontal scale is 1–2400000 and the vertical 1,000 fathoms (or 6,000 feet) to 1 inch (1–72000), making the ratio of scales 3:100; the size is about 5 by 4 feet. (In the illustration which accompanies this article the shading of the "dry land" has been reproduced after a photo graph, whilst the bottom of the ocean has been represented in vertical illumination, because the stereoscopic effect, which is the advantage of oblique illumination, would be lost in the vast proportions of the ocean, and the elimination of the connection between steepness of slope and intensity of shade to which our eye has become accustomed through usage, would seriously mislead.)

It has been stated in the article on "The Basin of the Gulf of Mexico" (Am. Jour. Sci., Vol. XXX, April, 1881) that the banks to the depth of 100 fathoms cover more than one-third of the surface (0.35) of the Gulf. On the Atlantic coast, the bank which starts in the Strait of Florida follows the entire coast line to the eastern extremity of Newfoundland. After leaving the Strait, it gradually expands until it attains a width of 75 miles off the coast of Georgia; at Cape Hatteras it is only 20 miles wide, but farther north it widens to 60 and 70 miles. After taking in the George's Shoal and Sable Island and suffering two interruptions by the passages to the Gulf of Maine and Gulf of Saint Lawrence, it reaches its greatest development in the Banks of Newfoundland, 260 miles out from Cape Race. Of that part of the Bay of North America which is represented upon the model, about the one-seventh part is less than 100 fathoms deep.

This line of 100 fathoms comprises the extensive area of level surfaces which generally extend for long distances beyond the coast line inland, and are relieved by the great slopes by which the ocean descends to the vast regions of its immense depth. These slopes constitute one of the most

striking features of the model; they have, and not inaptly, been called continental slopes, and the isobathic line of 100 fathoms the "continental outline."

In the Gulf of Mexico this slope goes down to a depth of about 1,500 fathoms, leaving nearly one-third of its area of a greater depth than 1,500 fathoms; in the Bay of North America, however, the slope goes down fully to the depth of 2,500 fathoms, leaving more than half the area represented at a greater depth. The mean depth of the Gulf of Mexico is 860 fathoms; excluding the banks, 1,280. For the Bay of North America 1,970 and 2,320 represent the corresponding figures. The greatest recorded depth in the Gulf of Mexico is 2,119 fathoms; in the Atlantic Ocean it is 4,561 fathoms, and is found about 70 miles to the northward of Porto Rico, and not very far from where the Challenger obtained its greatest depth of 3,875 fathoms. Aside from this great depth, which is quite abnormal, the greatest depth of the Northwest Atlantic varies from 3,000 to 3,100 fathoms. One of the peculiar features of submarine structure which has found expression in the model is the great steepness of slopes in the coral regions. The rise of the isolated Bermudas from a depth of 2,000 fathoms was already known from the Challenger soundings, but the discovery of the great depths of 2,700 to 2,900 fathoms along the Bahama Islands at distances of from 10 to 30 miles from, and consequently mostly within sight of, the outside islands was a surprise to the surveyor and cartographer alike.

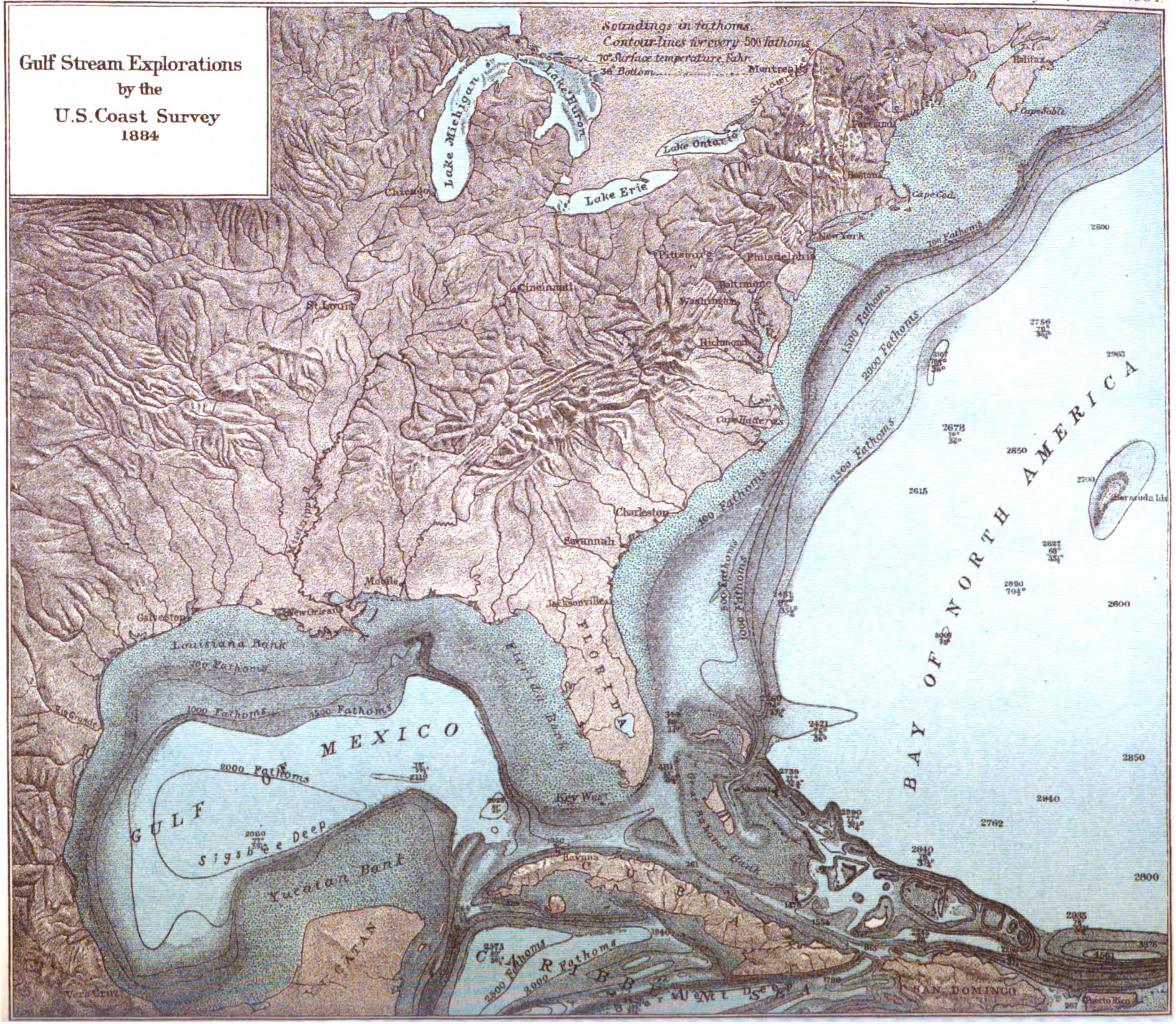
It also appears from the model that the Peninsula of Florida, the islands of Cuba, and the Bahama Banks are located within one great coral plateau which reaches nearly up to Cape Hatteras, and that they are separated by channels of relatively insignificant depths. In the celebrated Florida Strait or Gulf Stream channel we find a least depth of cross section of 439 fathoms, and a depth ranging from 465 to 265 fathoms, with hard, clean, coral bottom (the least depth about opposite Savannah) is maintained by the Gulf Stream to within 90 miles from Cape Hatteras, whence it rapidly increases to 2,000 fathoms. The old Bahama channel, which separates Cuba from the Bahamas, has 289 fathoms. The Providence channel, betweeen the Great and Little Bahama Banks, has not yet been thoroughly sounded, but a depth of about 350 fathoms appears probable.

It is not proposed to give a description of the continental portion of the model, but a few inferential statements will be made. The first impression obtained by even a casual comparison of the "land" and "water" portions of the model is the contrast afforded by the great diversity of shapes in the elevations (we may call it articulation) compared with the uniformity in the oceanic depressions. This contrast, however, is no matter of surprise when we consider the great part which that most important geological factor, *erosion*, has played in shaping the features of the continent. Almost the entire Mississippi Basin has been shaped by erosion. To this there is no analogous action under the surface of the sea, and there are only two or three instances where it would seem that we are able to trace the effect of erosion in the ocean. One is in the submerged valley of the Hudson River, off the entrance to New York Bay, the geology of which is discussed in Appendix No. 13 of this report; another one may be in a similar valley off Delaware Bay, just outside of Cape Henlopen, where a narrow channel of 25 fathoms depth in 9 fathoms of water terminates in a bar 14 fathoms deep 13 miles from the cape. The third instance is on the coast of Maine, where the effect of glacial erosion is believed to extend to depths of about 50 fathoms.

Another remarkable feature brought out by the model is the relative insignificance of terrestrial elevations contrasted with oceanic depressions. An elevation of 600 feet, equivalent to 100 fathoms, takes in the Atlantic plain, the Mississippi Valley, and the Texan plain, and reduces the continental area represented by about two-fifths (0.40). Taking another step of 600 feet (or 1,200 from the sea level), the area will be reduced by nearly the same amount (0.36), and leave about one-fourth (0.24) of the entire area with a height above 1,200 feet. This area comprises the Appalachian system, the highest parts of the table lands in Western Pennsylvania, Ohio, Indiana, and Michigan; also the copper region of Lake Superior, the western parts of Texas, the Indian Territory, and Kansas.

The mean elevation of that part of the continent represented in relief is about 720 feet. The mean depth of the Gulf of Mexico is therefore about seven times as great and that of the Bay of North America about sixteen times as great as this mean elevation. It is, however, proper to state that this mean elevation is very far below the mean height of the United States, which is computed

Coast and Geodetic Survey Report for 1884.



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ADDENDUM

To Appendix No. 17, Coast and Geodetic Survey Report for 1884.

In view of the great change in outline and size of the ocean, which an assumed reduction in depth of 100 fathoms would produce, it becomes a matter of interest to inquire into the changes which would attend the alteration of the level of the land to the same extent.

Assuming then the ocean to rise 600 feet (equal to 100 fathoms), we would find Nova Scotia not only separated from the continent but broken up into a number of small islands. The height of 600 feet will carry us up the Saint Lawrence to the Falls of Saint Mary's, between Lake Superior and Lake Huron, taking 602 feet as the elevation of Lake Superior and 581 as that of Lakes Huron and Michigan. The waters of the Saint Lawrence would be united with those of the Hudson by two channels, by the Lake Champlain and Mohawk Valleys, which rise to the moderate heights of 152 and 430 feet, respectively, Lake Ontario being at 247 feet. But the Great Lakes would also communicate directly with the Mississippi system, the "divides" in the vicinity of Chicago being only 7 and 9 feet above the surface of Lake Michigan, which is given by the "Lake Survey" at 581 feet above the sea.

Thus there would be two large islands cut off from the continent; one furrowed by the Connecticut, flanked on the east side by the White Mountains, and on the west side by the Blue Mountains. The other island, much smaller in extent, would have the Adirondacks as its backbone. The continent itself would be divided into an eastern and western part, the one characterized by the presence of the Alleghanies and the other one by the Rocky Mountains.

by Mr. Gannett at 2,600 feet (List of Elevations, &c., 4th edition, 1877). This difference is chiefly caused by the absence from the model of the Rocky Mountain system.

The following are the elevations of some of the highest peaks within the limits of the model:

	Feet.
Mount Washington (N. H.)	6, 293
Mitchell's High Peak (N. C.)	6, 688
Orizaba Peak (Mexico)	17, 879
Popocatepetl (Mexico)	17, 784
Pico de Tarquino (Cuba)	8, 400
Pico de Yaqui (San Domingo)	9, 695

PROGRESS SKETCHES.

ILLUSTRATIONS.

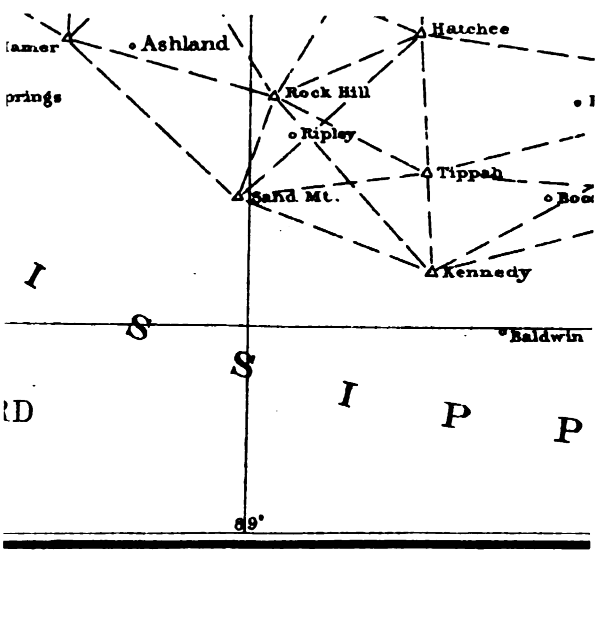
3

72°00'

°20'

67° 00'

4

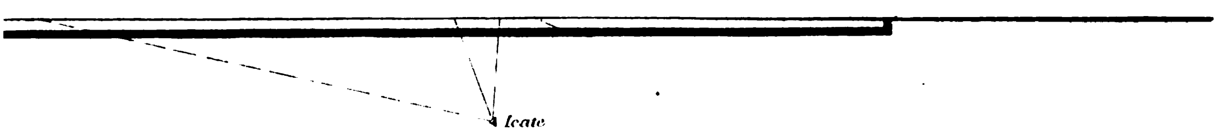

Ashland
Hatchee
Rock Hill
Ripley
Tippah
Sand Mt.
Kennedy
Baldwin
I S S I P P
89°

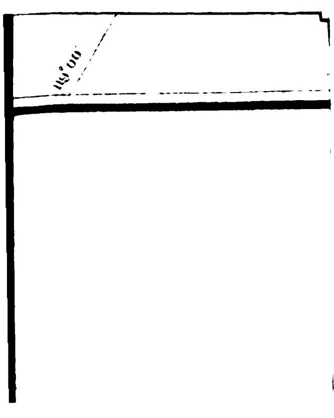
7 B

81°10′

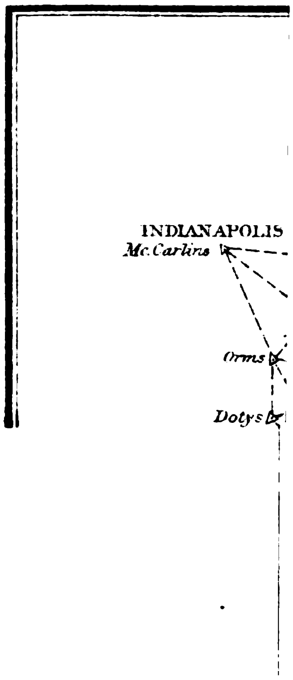
90°00′

10



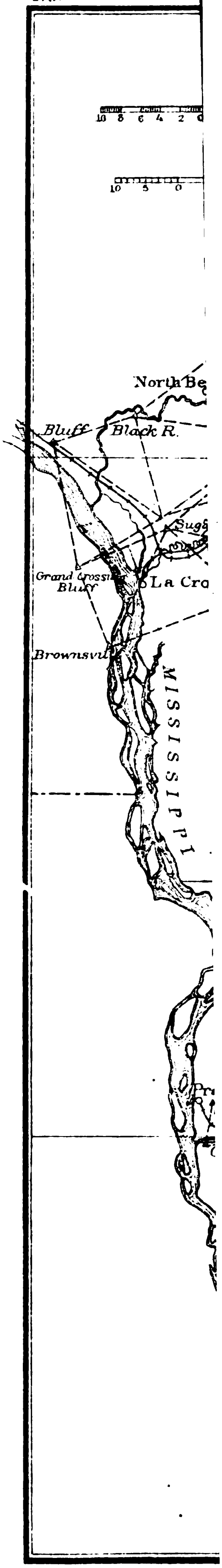


No. 15

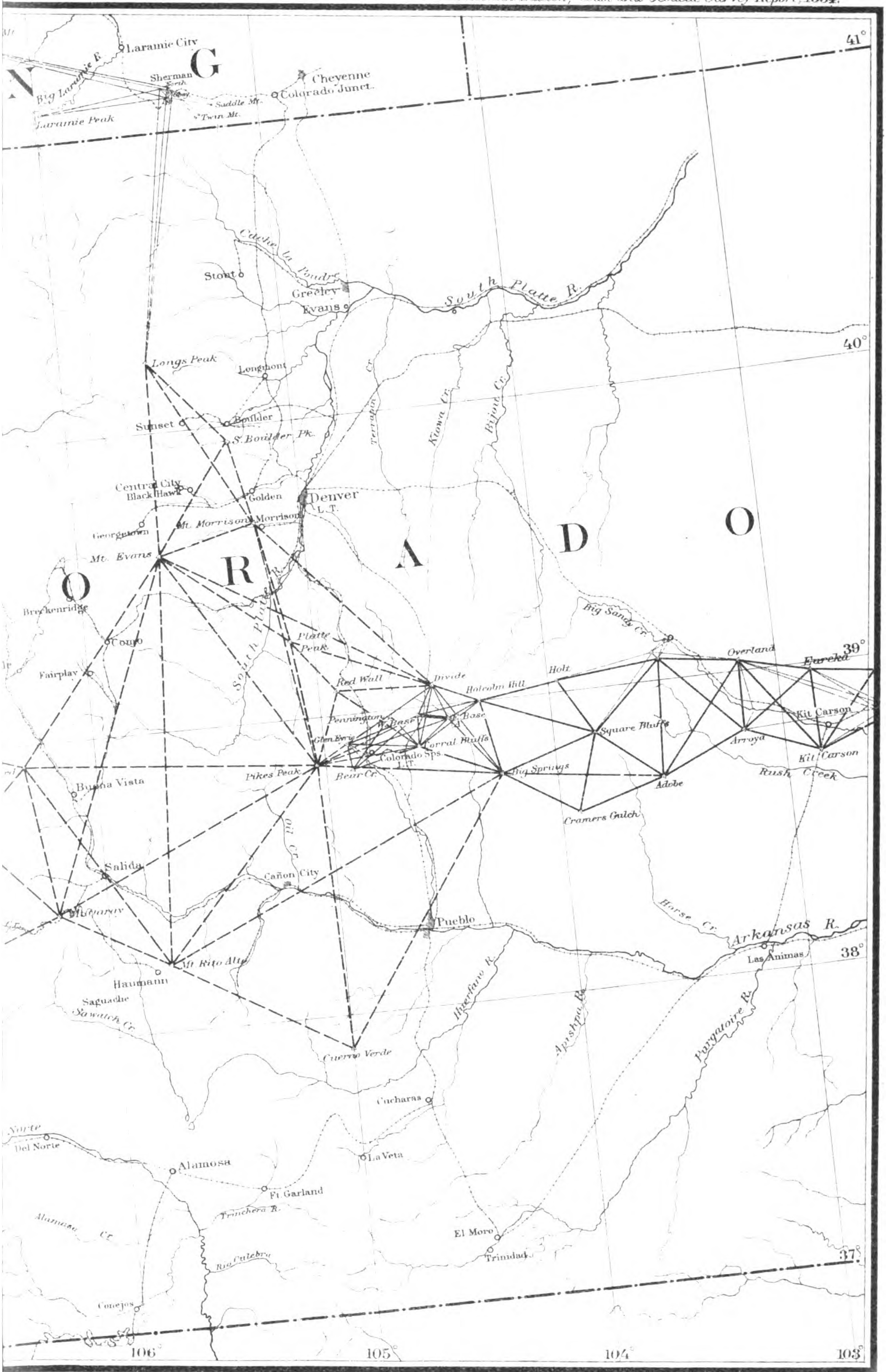


No. 16

16


North Be
Bluff
Black R.
Grand Crossing Bluff
La Cro
Brownsvi
MISSISSIPPI

94°00′



41°
40°
39°
38°
37°
106°
105°
104°
103°
G
O R A D O
Laramie City
Laramie R.
Big Laramie R.
Sherman
Cheyenne
Colorado Junct.
Saddle Mt.
Twin Mt.
Laramie Peak
Cache la Poudre
Stout
Greeley
Evans
South Platte R.
Longs Peak
Longmont
Sunset
Boulder
S. Boulder Pk.
Terrapin Cr.
Kiowa Cr.
Bijou Cr.
Central City
Black Hawk
Golden
Denver
L.T.
Georgetown
Mt. Morrison
Morrison
Mt. Evans
Breckenridge
Como
Fairplay
South Platte R.
Platte Peak
Big Sandy Cr.
Overland
Eureka
Holt
Divide
Holcolm Hill
Red Wall
Pennington
Base
Glen Eyrie
Corral Bluffs
Colorado Sps
L.T.
Bear Cr.
Pikes Peak
Big Springs
Square Bluffs
Arroya
Kit Carson
Adobe
Rush Creek
Cramers Gulch
Buena Vista
Salida
Oil Cr.
Cañon City
Pueblo
Horse Cr.
Arkansas R.
Las Animas
Mt Rito Alto
Haumann
Saguache
Sawatch Cr.
Huerfano R.
Apishpa R.
Purgatoire R.
Cuerno Verde
Cucharas
Del Norte
Alamosa
La Veta
Ft. Garland
Trinchera R.
Alamosa Cr.
El Moro
Trinidad
Rio Culebra
Conejos


B
20°
80°